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ABSTRACT

This 10-chapter report presents information on the 1986 assessment of students' science performance in the province of Manitoba in Canada. The assessment was intended to provide a broad base of accurate information on the performance of grade 3, 6, and 9 students. The program of studies for Manitoba schools is designed to educate the student in science over a wide range of science goals and objectives that go well beyond knowledge of science content. Tests were developed to survey student performance on the knowledge, understanding, skills, and attitudes that form the Manitoba Science Curriculum. The student assessment included two components. A written component contained cognitive and affective questions. A performance component required students to apply science skills, knowledge of science concepts, and the ability to use common laboratory equipment and techniques. A survey of science teachers in grades 1-6 was conducted in conjunction with the student assessment to provide teacher information that would complement the student data. The results of these tests were considered in light of the 1980 Science Assessment results. Appended are a sampling design and results of the teacher questionnaire. (KR)

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MANITOBA SCIENCE ASSESSMENT

1986

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FINAL REPORT

U.S. DEPARTMENT OF EDUCATION

Manitoba
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5E

MANITOBA SCIENCE ASSESSMENT 1986

FINAL REPORT

ENGLISH LANGUAGE AND FRENCH IMMERSION PROGRAMS

A REPORT OF THE
CURRICULUM DEVELOPMENT AND IMPLEMENTATION BRANCH
MANITOBA EDUCATION

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Winnipeg 1988

PREFACE

The process for the development of the Science Assessment materials was begun in March, 1985. At this time two science educators, Dr. Sylvia Leith and Dr. Ken Slentz, were contracted to produce the actual testing instruments and to assist in the development of the Final Report. A committee of teachers experienced at teaching science at the appropriate grade levels was convened to advise on all aspects of the test development and the reporting of the provincial results.

Purposes

As with the other assessment programs, the Science Assessment was intended to provide a broad base of accurate and current information on the performance of students in Grades 3, 6, and 9. The purposes of all provincial assessments are:

1. To provide benchmark indicators about the level of student achievement in the Province of Manitoba.
2. To obtain data on student achievement that will assist in curriculum and program improvement, both at the provincial and local level.
3. To assist school divisions in both student and system evaluation.
4. To help teachers improve their student evaluation skills.

Components of the Science Assessment

There are four major components to the Science Assessment Program: Written testing, Performance testing, Teacher Survey, and 1980-85 Comparison testing. The Written and Performance components were administered to students in Grades 3, 6, and 9 in the spring of 1986. The teacher survey administered in spring of 1986 consisted of a questionnaire given to teachers of science at Grades K to 6, (teachers in Grades 7-9 were surveyed in the spring of 1985). The 1980-85 comparison testing consisted of a re-administration of selected portions of the 1980 tests to Grade 5, 8, and 11 students in November of 1985.

Reporting of the Science Assessment

The Science Assessment was based on the objectives of the Manitoba Science curriculum as well as the input of teachers who attended meetings held throughout the province. The results are reported on a provincial basis only, and no individual students, schools, or school divisions are identified. Conclusions and recommendations for the written test component were based on the interpretations of results by experienced science teachers and other educators of science at Grades 3, 6, and 9.

A Preliminary Report on the Science Assessment was released in October, 1986. This Report only provided data on the test items.

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- The Joint Committee on Evaluation which provided guidance throughout the program;
- The Science Technical Advisory Committee which advised on test production and analysis of results;
- The Science Interpretation Panels;
- The teachers and others who participated in the review of objectives;
- The school administrators, teachers, and students who were involved in the pilot testing;
- The teachers who participated in the teacher surveys;
- The divisions and schools that released their teachers to assist in the program;
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- The artist, Eleanor Hannan, who did the art work for the Grade 3, Grade 6, and some of the Grade 9 tests.

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- Drs. L. Graham, D. Anderson, and R. Connor of the Faculty of Science, University of Manitoba.
- Drs. T. Meadows and H. Grunau of the Faculty of Education, University of Manitoba.

A WORD OF CAUTION ABOUT THE ASSESSMENT PROGRAMS

All assessments of knowledge and attitudes are subject to errors of measurement. These errors can occur in a number of ways: the specification of skills and objectives, the selection of materials and production of test questions, the weighting of questions, the interpretation of results. In the assessment program, effort has been made to minimize errors. The intent of the assessments is to obtain estimates of the performance of Manitoba students as a group on a variety of objectives in the program. The tests are not designed for individual student diagnosis or grading, but rather to provide an indication generally of strengths and weaknesses in the program. Teacher evaluation of students should be based on a number of observations and evaluations made on the students throughout the year.

TABLE OF CONTENTS

Page

PREFACE . . . iii

COMMITTEES AND GROUPS ASSOCIATED WITH THE ASSESSMENT. . . . iv

ACKNOWLEDGEMENTS. . . . vi

1. THE SCIENCE ASSESSMENT PROGRAM. . . . 1
    - STEPS IN THE SCIENCE ASSESSMENT PROGRAM . . . 2
    - NATURE OF THE ASSESSMENT . . . 6

2. GRADE 3 WRITTEN COMPONENT RESULTS. . . . 9
    - A. CONTENT OF SCIENCE . . . 9
        - RESULTS OF THE ASSESSMENT VIEWED THROUGH CONTENT THEMES. . . 15
    - B. PROCESSES OF SCIENCE . . . 16
    - D. PROBLEM SOLVING AND DECISION MAKING. . . . 20
        - SUMMARY OF THE COGNITIVE CATEGORIES OF THE TEST. . . . 22
    - E. ATTITUDE TOWARD SCIENCE. . . . 23
    - F. SCIENCE AND SOCIETY. . . . 26
        - SUMMARY OF E. ATTITUDE TOWARD SCIENCE AND F. SCIENCE AND SOCIETY. . . . 28
        - SUMMARY OF GRADE 3 RESULTS ON THE WRITTEN TEST . . . 28

3. GRADE 3 PERFORMANCE COMPONENT RESULTS. . . . 31

4. GRADE 6 WRITTEN COMPONENT RESULTS. . . . 47
    - A. CONTENT OF SCIENCE . . . 47
        - RESULTS OF THE ASSESSMENT VIEWED THROUGH CONTENT THEMES. . . 53
    - B. PROCESSES OF SCIENCE . . . 54
    - D. PROBLEM SOLVING AND DECISION MAKING. . . . 57
        - SUMMARY OF B. PROCESSES OF SCIENCE, AND D. PROBLEM SOLVING AND DECISION MAKING. . . . 60
    - E. ATTITUDE TOWARD SCIENCE. . . . 61
    - F. SCIENCE AND SOCIETY. . . . 66
    - G. NATURE OF SCIENCE. . . . 67
        - SUMMARY OF E. ATTITUDE TOWARD SCIENCE, F. SCIENCE AND SOCIETY, AND G. NATURE OF SCIENCE. . . . 69
        - SUMMARY OF GRADE 6 WRITTEN TEST RESULTS . . . 69

5. GRADE 6 PERFORMANCE COMPONENT RESULTS. . . . 71

6. GRADE 9 WRITTEN COMPONENT RESULTS. . . . 87
    - A. CONTENT OF SCIENCE . . . 87
        - SUMMARY FOR CONTENT OF SCIENCE . . . 92
    - B. PROCESSES OF SCIENCE . . . 93
        - SUMMARY FOR PROCESSES OF SCIENCE . . . 94
    - C. SKILLS FOR SCIENCE . . . 94
        - SUMMARY FOR SKILLS IN SCIENCE. . . . 97
    - D. PROBLEM SOLVING AND DECISION MAKING. . . . 97
        - SUMMARY FOR PROBLEM SOLVING AND DECISION MAKING. . . . 100
    - E. ATTITUDE TOWARD SCIENCE. . . . 100
    - F. SCIENCE AND SOCIETY. . . . 104
        - SUMMARY OF SCIENCE AND SOCIETY . . . 106
    - G. NATURE OF SCIENCE. . . . 107

7. GRADE 9 PERFORMANCE COMPONTENT RESULTS . . . 109

8. SCIENCE COMPARISON TESTING 1980-85 . . . 127

9. SCIENCE TEACHER SURVEY . . . 137

10. SUMMARY AND RECOMMENDATIONS. . . . 151

APPENDICES

1. COMPARISON TESTING SAMPLING DESIGN . . . 162
2. TEACHER QUESTIONNAIRE RESULTS . . . 167

CHAPTER 1

THE SCIENCE ASSESSMENT PROGRAM

The 1986 Science Assessment Program was designed for and administered to three grade levels, Grades 3, 6 and 9. The Assessment was intended to provide a broad base of accurate and current information on the performance of students in Manitoba. The program of studies for Manitoba schools is designed to educate the student in science over a wide range of science goals and objectives that go well beyond knowledge of science content. The tests were developed to survey student performance on the knowledge, understanding, skills, and attitudes that form the Manitoba Science Curriculum.

The Science Assessment included two components in the testing of students. One was a written component which contained cognitive and affective questions. The other was a performance component which required students to apply science skills, knowledge of science concepts, and ability to use common laboratory equipment and techniques.

Measurable science objectives were abstracted from the Manitoba K-6 and 7-9 Curriculum Guides and elicited from suggestions by teachers throughout the province. Test questions were developed based on these objectives and suggestions, and the student results were analyzed relative to these objectives. The results provide an indication of student performance for a number of curricular areas in each of Grades 3, 6, and 9. All results are reported on a provincial basis only, with no identification of any individual students, schools, or school divisions. A survey of science teachers in Grades 1-6 was conducted in conjunction with the assessment to provide teacher information that would complement the student achievement data. A comparison test was given in November, 1985. This test utilized selected items from the 1980 assessment and was given to Grades 5, 8 and 11. The results of this test were considered in light of the 1980 Science Assessment results.

STEPS IN THE SCIENCE WRITTEN ASSESSMENT PROGRAM

Following establishment of the Science Technical Advisory Committee (TAC) and the acquisition of the science test contractors (Dr. Leith and Dr. Slentz), the steps involved in the Science Assessment Program were:

Step One: Identification of Goals and Objectives

Development of materials for the science assessment began with the identification of the goals for science programs from kindergarten through grade 9. These were abstracted from the Manitoba Education Curriculum Guides and greatly assisted the science test contractors and the Science Technical Advisory Committee in making the decision for determining what skills, knowledge, and attitudes were to be assessed.

Once the overall goals for the science assessment were established, the science test contractors produced an extensive list of specific measurable objectives based on those goals that were judged appropriate to the grade levels being tested.

Step Two: Verification and Selection of Objectives

Science teacher representatives from each School Division and District rated the importance for assessment of both the assessment goals and the specific objectives. This occurred at a series of regional meetings held in locations throughout Manitoba. Teachers at these meetings reviewed, supplemented, and rated the science objectives, suggested methods of assessment and indicated additional information that would be useful to collect from teachers.

Data from the regional meetings were compiled to assist in the determination of the final list of specific objectives for which test items were subsequently written.

Step Three: Production of Tests

The Science TAC recommended a format for the tests based on the input of science teachers at the regional meetings. Items were written by the contractors according to the format selected using the objectives identified. The contractors were also guided by the need to write items for the various categories, as well as the need to ensure that the readability level was appropriate. Multiple-choice and written-response items were used throughout with the exception of the attitude items which included Likert-type items with three to five response choices from "strongly agree" to "strongly disagree".

Pilot test items were reviewed twice by the Science TAC. Initial modifications, additions, and deletions were based on readability, accuracy of science content, general suitability for the grade levels, and the technical quality of the items. Item analyses of pilot test results formed the basis for a further review. Inappropriate items were deleted or modified, and the tests were shortened. Comments from teachers at the pilot schools were also considered in this review. The science test contractors revised the tests and constructed an administration manual and key for each grade.

The test instruments for science were developed for the three grade levels in both the French and English languages. Production of two versions of an assessment instrument in different languages is a complex procedure involving more than mere translation. The Science TAC membership included French language science teachers and the Bureau de l'Education Française science consultant. They assisted in test development, and made recommendations on test construction, based on input from the French language teachers of science.

Final tests, and administration and scoring manuals were developed by the contractors and these were printed and distributed to schools by Manitoba Education.

Step Four: Provincial Administration of Tests

Approximately ten percent of all students in grades 3, 6, and 9 in Manitoba's public schools were designated in advance for the provincial sample. Students eligible for the sample were all those enrolled in public schools in grades three, six, and nine. Schools were asked to indicate whether they wished to test all students in their classes or test only those designated for the provincial sample, and whether they required French language or English language versions of the tests.

Schools were requested to return those tests designated by the Department for the provincial sample. The actual sample of student tests analyzed was approximately 90% of the designated sample. The sample loss was due primarily to student absence and transfer, as indicated on the returned sample lists. Table 1 indicates the provincial sample of tests at each grade level.

TABLE 1
PROVINCIAL SAMPLE OF TESTS: ENGLISH AND FRENCH IMMERSION

Grade	Number of Students Eligible	Tests Scored (Sample)	
		Total	Percentage of students in province
3	14161	1294	9.1%
6	14412	1335	9.3%
9	14387	1198	8.3%

Step Five: Reporting of Test Data

A detailed presentation of the student data collected for the Written component of the Assessment was mailed to schools in October, 1986. The data were presented in tabular form and were accompanied by a minimum of discussion as the report was designed only to provide basic information on student data for use by classroom teachers.

Step Six: Interpretation of Results

The assessment results are estimates of levels of performance of students, but these levels must be evaluated as to their quality and/or adequacy. Criterion performance levels based on general rules--e.g., "50% correct is necessary to pass an objective"--are arbitrary and are not dependent on the objective in question. Thus, performance levels were adjudicated in a different manner.

Because the written Science Assessment tests were designed to assess a number of separate goals, performance expectations and interpretations were made for each of the test items and science goals. Working in grade groups, the Interpretation Panels estimated two levels of performance, "adequate" and "desirable", for each test item (except attitude items) according to the following definitions:

> "Adequate" performance - the minimum percentage of students in the province which you feel must complete an item correctly in order for performance to be considered satisfactory. Performance below the adequate level would, in your opinion, be considered indicative of a weakness.

> "Desirable" performance - the percentage of students in the province which you would like to see complete an item correctly--a goal toward which to strive. Performance at or above the desired level would, in your opinion, be considered as indicative of a strength.

After estimating these two levels of performance for each item, each grade group then made interpretation ratings regarding the obtained student results. Using the previously established "adequate" and "desirable" levels of performance as a guide for making judgments, they rated the student performance (obtained percentage correct) for each category subtest according to a five-point scale as follows:

Strength
Very Satisfactory
Satisfactory
Marginally Satisfactory
Weakness

The group then examined interpretation ratings of all items for a particular goal, and made an interpretation rating for overall performance on that goal. Participants summarized and interpreted the identified strengths and weaknesses for each goal and made comments regarding performance on the goal. The final task in interpreting the results was the generation of educationally relevant, specific recommendations.

The procedure for judging student performance involves making estimates and ratings for each test item. Therefore, it is likely that some items that have lower percentage correct scores may have received a higher interpretation rating than other items that have higher percentage correct scores. Because of varying levels of difficulty of items it was quite possible to have an item with less than 50 percent correct being rated "very satisfactory" whereas for another item a 75 percent correct response may be considered "marginally satisfactory".

The questions in the cognitive domain were considered for Panel interpretation. Interpretation ratings were not made for the attitude items: these results should be considered as responses to an opinion survey only. However, in the affective domain, the Interpretation Panel viewed the overall total responses as favorable or unfavorable for each grade level.

The median interpretation ratings for items and for goals, and the recommendations resulting from Interpretation ratings, have been used as a basis for this report. Interpretive information and conclusions are presented together with more comprehensive findings and recommendations.

For the performance tests the students' results were reported only according to their success in all the various aspects of the items. No estimations of expectations were made.

NATURE OF THE ASSESSMENT

The student tests were designed to assess science knowledge, understanding, and skills, and to report the perceived attitudes of students as related to the provincial science curricula.

The major categories in the assessment framework identified for the assessment were:

A - Content of Science
B - Processes of Science
C - Skills for Science
D - Problem Solving and Decision Making
E - Attitude toward Science
F - Science and Society
G - Nature of Science

There were a series of subtests or sub-categories for each major category as noted by Table 2 below.

The tests also encompassed the grade 3, 6 and 9 science themes as specified in the curriculum. The tests in grades 3 and 6 contained test questions in the three major areas of study, Earth and Space Science, Physical Science, and Life Science. The grade 9 Science test included questions from the specified six areas of the curriculum: Environmental Science, Life Science, Earth Science, Space Science, Physics, and Chemistry.

Table 2

Categories of Science Assessed by the Written Component Tests

Categories	Number of Items		
	Grade 3	Grade 6	Grade 9
A. CONTENT OF SCIENCE			
1. Facts	10	13	14
2. Terminology	8	9	11
3. Concepts/Relationships	6	10	9
4. Theories and Conceptual Schemes	1	5	4
5. Explanation of Physical Phenomena	5	3	2
6. Trends and Sequences	2	3	3
B. PROCESSES OF SCIENCE			
7. Observing and Classifying	9	5	
8. Measuring/Quantifying	7	4	
9. Identifying, Collecting, Interpreting, Reporting Data	8	11	25 (combined for all processes)
10. Making Inferences/Hypothesizing	5	10	
11. Building, Testing, and Revising Theoretical Models	no items	4	
C. SKILLS FOR SCIENCE			
12. Skills Using Laboratory Equipment	no items	no items	14
13. Skills Associated with Safety	no items	no items	7
D. PROBLEM SOLVING AND DECISION MAKING			
14. Cognition	2	3	4
15. Following Instructions/Using Algorithms	no items	no items	5
16. Using Inquiry Techniques	no items	7	4
17. Application of Knowledge	3	3	2
E. ATTITUDE TOWARD SCIENCE			
18. Enjoying Science	5	5	3
19. Valuing Science	4	8	4
20. Adopting Attitudes of Science	3	3	9
21. Making Career Decisions	2	7	16
F. SCIENCE AND SOCIETY			
22. Science in Canada	no items	no items	10
23. Health, Nutrition and Agriculture	3	4	5
24. Environment	3	4	2
25. Energy	1	2	3
26. Recreation	no items	no items	no items
G. NATURE OF SCIENCE			
27. History of Science	no items	8	10
28. Philosophy of Science	no items	no items	1
TOTAL	87	131	167

CHAPTER 2

GRADE 3 WRITTEN TEST RESULTS

The Grade 3 results for the Written Component of the Assessment are presented for six of the seven categories as set out in Table 2 on page 7. These categories are A. Content of Science, B. Processes of Science, C. Skills for Science, D. Problem-Solving and Decision-Making, E. Attitude Toward Science, F. Science & Society. The seventh category, which is not discussed here, is G. Nature of Science. The tables present the results for the categories under each major heading assessed and include the item numbers, the number of items, the mean raw score, the standard deviation, the mean percent correct, and the rating given by the Interpretation Panel for the category. Each category within each major heading is then summarized and an example item is often presented to illustrate student performance in the category.

A. Content of Science

Students' learning of science content is categorized according to a hierarchy of cognitive levels. From lowest to highest these are facts and terminology, concepts/relationships, theories and conceptual schemes, explanation of physical phenomena, and trends and sequences. The student achievement results for the Content of Science are summarized below in Table 3.

Table 3

Results for Grade 3. A. Content of Science

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Mean Percent	Panel Rating
1. **Facts**	56-65	10	7.16	2.55	72%	Satisfactory
2. **Terminology**	66-73	8	4.92	2.00	62%	Satisfactory
3. **Concepts**	74-79	6	4.12	1.39	69%	Very Satisfactory
4. **Theories**	80	1	0.63	0.48	63%	Very Satisfactory
5. **Explanation**	81-85	5	1.90	1.15	38%	Satisfactory
6. **Trends**	86-87	2	0.94	0.79	47%	Unsatisfactory
Total		32	19.67	5.74	61%	*

* No summary interpretation by the Interpretation Panel.

Content A1. Facts. Facts were defined as being at the recall level according to Bloom's cognitive taxonomy. Students obtained a mean score of 72% correct for the 10 items. The Interpretation Panel rated this score as Satisfactory. These items covered several content themes and the students appeared to know many of the facts in the themes.

The Facts items were of the type where students had to provide a written answer or to select the letter representing an object in a picture and place it alongside the correct description. Students generally did well on these items although 3% to 18% did not respond to the items. For example, in the question below where two responses were required, 6% of students did not give any response (#56) and 18% did not give a second response (#57).

56/57) Tell two ways that a mammal is different from a bird.

Category A2. Terminology. Items in the terminology category were designed to be at the comprehension level of Bloom's Taxonomy. The questions in this category generally ask for some understanding of terms. The mean score for this category was 62% which the Panel rated as Satisfactory.

The Terminology questions were of multiple-choice and matching format. The example below required students to connect a term with a defining characteristic, 76%, 72%, and 64% answered items 68, 69, and 70 correct respectively. Some students were reported to have confused the term "gas" with "gasoline".

Achievement in this category was satisfactory, although students had some difficulty with technical usage of certain terms.

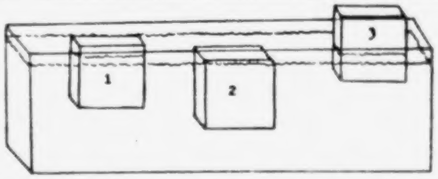
Draw lines to match the words in I with their meanings in II.

	I	II
68)	**solid**	**A) has no definite shape**
69)	**liquid**	**B) can be stacked up**
70)	**gas**	**C) can be poured in drops**

Category A3. Concepts/Relationships. Concepts have been defined as the nucleus about which scientific knowledge is organized. Concepts and relationships are considered to be above the level of comprehension in the hierarchy of Bloom's taxonomy. Students had a mean score of 69% correct. This was judged as Very Satisfactory by the Interpretation Panel.

Students did very well on some of the items in this category. Over 82% were able to identify the heaviest of three objects floating in a dish of water (see #79 below).

79)



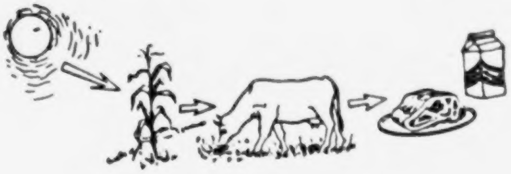
The three solid objects shown are the same size. If they float as shown in the picture, which one is the heaviest?

1% A) Object 1
*** 83% B) Object 2**
10% C) Object 3
4% D) They all weigh the same.

*indicates correct answer

This category included both written response and multiple choice items. The lowest percentage correct was for the written-response item based on the concept of "Interdependency". In item #75 illustrated below approximately 49% of students wrote a correct answer. Most children attempted this item. Only 4% did not respond.

75)

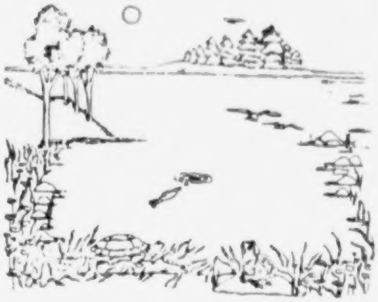


The cow produces milk and meat. The cow eats grass and grain. Tell what can happen to people if the cow doesn't get enough food to eat.

Category A4. Theories and Conceptual Schemes. Theories in science may be thought of as research-supported explanations of physical or natural phenomena. A conceptual scheme is an ordering of concepts according to a particular logic. For a student to be able to discuss theories and conceptual schemes he/she is considered to be operating at Bloom's higher levels of thinking. The students obtained a mean score of 63% for this category. The Interpretation Panel rated this as Very Satisfactory.

These results must be interpreted cautiously because there was only one item in the category. This item dealt with the theory of "Interdependency and Interaction among Organisms". Most children attempted the item -- only 7% did not respond; 63% answered correctly. The item follows:

80) Different populations in a community interact with each other. Tell how the populations in the picture may change if the plants die.



Category A5. Explanation of Physical Phenomena. This category is broader than formulating a theory or conceptual scheme since some explanations may involve several theories or conceptual schemes. Higher level thinking skills are required. The mean score correct for this category was 38%.

The Interpretation Panel considered that, of the five items, the two items dealing with molecules of air (#83,84) were too difficult for children in Grade 3 and therefore should not be considered in rating the category. Student scores on the other three items were rated as Satisfactory by the Panel.

Category A6. Trends and Sequences. This category contained items relating the students' knowledge of science to common trends occurring in today's technological society. The mean score for this category was 47% which was rated Unsatisfactory by the Interpretation Panel. The Panel stated that the trend represented in the item was a very important one for the children to know.

The results should be interpreted cautiously since the category contained only one item (below) which required two responses. The students did very poorly in giving the second response; 19% of students did not give a second response. Those who did respond scored only 38%.

(86/87) Some animals and plants have already become extinct. What can people do to help stop this from happening? Write two things they can do.

Summary of Results for The Major Heading A. Content of Science

The Grade 3 students generally performed well on the six categories of content; their total mean score was 61% for items under this heading. Students scored better in those categories at the lower levels of Bloom's taxonomy. They scored worst in the higher cognitive level categories, Explanation of Physical Phenomena and Trends and Sequence (38% and 47% respectively). As noted earlier, the results in these two categories should be interpreted cautiously since they are based on relatively few questions, and two of the items in the Explanation category were considered beyond the level of Grade 3 students.

The results for the category, Concepts, are encouraging. The mean of 69% was interpreted as a Very Satisfactory performance. Overall, the Grade 3 students achieved well on the Facts, Terminology, and Concepts of the Science program according to this test.

The Interpretation Panel did express a concern about the students' knowledge of science terms. Some of the precise distinctions among terms are not well understood, e.g., "gas" and "gasoline".

Students did not seem to have much difficulty responding to different formats of items in the test. They did have some difficulty providing more extensive written responses, particularly explanations, and often did less well on the second part of an item. The number of students who left an item blank (No Response) was higher for the Explanation category (over 16%) and usually higher for the second part of an item.

Results of the Content Items Categorized According to Content Themes

The objectives of the Manitoba K-6 Science curriculum are organized into three content themes: Interdependency and Interaction among Organisms; Changes in Matter and Energy; and Earth, Space and Time. The 32 items of the Assessment that are included under the heading A. Content of Science, were further categorized according to the three themes. The mean scores of items for each category and theme are presented along with Interpretation panel ratings in Table 4 below.

Table 4
Results of Grade 3. Content Themes

Theme	Category	No. of Items	Mean Percent	Panel Rating
Interdependency and Interaction among Organisms	1. Facts	5	68%	
	2. Terminology	2	69%	
	3. Concepts	2	65%	
	4. Theories	1	63%	
	6. Trends	2	47%	
Total for Theme		**12**	**64%**	**Satisfactory**
Changes in Matter and Energy	1. Facts	4	75%	
	2. Terminology	6	59%	
	3. Concepts	3	76%	
	5. Explanations	4	29%	
Total for Theme		**17**	**59%**	**Satisfactory**
Earth/Space/Time	1. Facts	1	73%	
	3. Concepts	1	56%	
	5. Explanations	1	73%	
Total for Theme		**3**	**67%**	**Satisfactory**

The mean score of Grade 3 students was slightly higher for the Interdependency and Interaction Theme (64%) than for the changes in Matter and Energy Theme (59%). The Panel rated student performance as Satisfactory for all three themes. The mean score for the Earth, Space, and Time theme is based on only three items so should be interpreted cautiously.

B. Processes of Science

The students' ability was assessed in a hierarchy of process skills including the basic processes of observing, measuring, identifying and collecting data, and the more complex processes of interpreting data, and inferring. Students performed well for all four categories which were tested under this major heading: the mean score for all items was 72%. The Interpretation Panel rated performance in all categories as Satisfactory or above. The results are summarized below in Table 5.

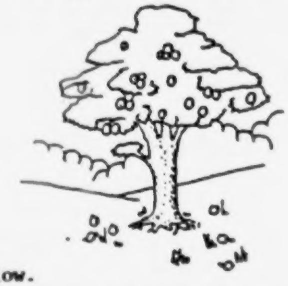
Table 5
Results of Grade 3. B. Processes of Science

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Mean Percent	Panel Rating
7. **Observing**	1-9	9	6.88	1.65	76%	Satisfactory
8. **Measuring**	10-16	7	4.60	1.44	66%	Satisfactory
9. **Identifying**	17-24	8	6.14	1.73	77%	Very Satisfactory
10. **Making Inferences/Hypothesizing**	25-29	5	3.59	1.15	72%	Satisfactory
Whole Process Area		**29**	**21.21**	**4.53**	**72%**	**Satisfactory**

Category B7. Observing/Classifying. Skills in this category require students to observe features in their environment by using their appropriate senses. Classification of objects occurs after noting the similarities and differences. The students' mean score for this category was 76% which the Interpretation Panel rated as Satisfactory.

All items in this category contained pictorial illustrations as well as text to provide students with information. The proportion of students obtaining the items correctly ranged from 52% to 89% for the nine items. For the item with the lowest correct score, students were directed to observe a picture (see below) and tell what they thought was sure to be true. Slightly over half of the students, 52%, selected the correct option (B), while the others selected options A, C, or D, each of which included inferences.

4) **Look at this picture of an apple tree in a field.**



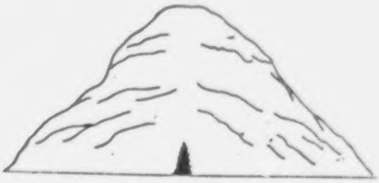
Read the sentences below.
Just by looking at the picture which one can you be most sure is true?
Please [√] the best answer.

__29%__ **A) The wind had knocked some apples off the tree.**
*__52%__ **B) There are apples on the ground and on the tree.**
__10%__ **C) The apples on the tree are ready for picking.**
__7%__ **D) The apples on the ground are spoiled.**

Category B8. Measuring/Quantifying. This category consisted of items dealing with measuring skills. The questions dealt with various types of estimation and measurement -- length, volume and temperature. The students' mean success rate was 66% and the Interpretation Panel rated this score as Satisfactory.

Students did well on a number of items which required them to compare lengths (#11) and temperatures (#15), identify the best device to measure the length of an object (#12), and to use a ruler (#13). They did poorest on two items, one requiring them to indicate the amount of liquid in a measuring cup using interpolation (32% of students correctly answered this item) and the other (#10 below) requiring them to estimate the height of a hill using a tree (41% correctly answered this question).

10) Use the tree as a measure. How many trees high is the hill? Check [✓] the best answer.



41% A) 4 trees
*** 41% B) 5 trees**
11% C) 6 trees
5% D) 7 trees

Category B9. Identifying, Collecting, Interpreting, Reporting Data. Items in this category required students to read and interpret information presented in charts, tables, and graphs. The mean score was 77%, which was rated by the Interpretation Panel as Very Satisfactory.

Students were able to interpret the information presented in the charts, tables, and graphs. The only difficulty they had was with an item that required recognizing the correct graph which represented a chart of information.

Category B10. Making Inferences/Hypothesizing. The items included for this category required making inferences and predicting; hypothesizing was not assessed since it was considered beyond the Grade 3 level. The Interpretation Panel rated the mean score of 72% as Satisfactory.

Students did well on an inference item that required them to infer the possible cause of an accident depicted in a picture. As well, they could predict the next step in a sequence depicting the growth of a flowering plant (83% obtained #29 correct). Approximately 69% could select the expected temperature based on the pattern from the data table below, but over 15% chose options A or B suggesting that some students did not recognize the pattern of the data. The next item required students to select a possible explanation for the rise in temperature depicted in #26. Almost 25% selected the response that the water was sitting on a desk. This suggests that they may not know the relationship of 30 degrees Celsius to room temperature.

26) Karen and Linda did a project in science class. They recorded the temperature of water each minute. This chart shows what they found.

TIME	TEMPERATURE
1 minute	18°C
2 minutes	22°C
3 minutes	26°C
4 minutes	30°C
5 minutes	?°C

What do you think the temperature of the water will be at five minutes?

9% A) 26°C   14% C) 32°C

6% B) 29°C   * 69% D) 34°C

*Indicates correct response

27) Use the chart from the last question. What is the best reason for what happened?
Check [√] the best answer.

*** 48% A) The water was on a hot stove.**
16% B) The water was in a cooler.
24% C) The water was sitting on a desk.
9% D) The water was outside under a tree.

***Indicates correct response**

D. Problem Solving and Decision Making

In order to discover the children's ability to do problem solving and decision making they were presented with word situations or problems for which they had to identify the problem or apply scientific knowledge to suggest a possible solution to the problem. In all cases real life problems were used, rather than problems they would have encountered through their science program. Only the categories Cognition, and Application of Knowledge were assessed at this grade. Although the students' mean scores on the two categories were low, the Panel rated both as Satisfactory. The results are summarized in Table 6.

Table 6

Results of Grade 3. D. Problem Solving and Decision Making

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
14. Cognition	30-31	2	0.95	0.70	47%	Satisfactory
15. Application	32-24	3	1.11	0.88	37%	Satisfactory
Total Problem Solving		**5**	**2.05**	**1.24**	**41%**	**Satisfactory**

Category D14. Cognition. This category deals with the perception of a problem as a problem. It also includes the ability to select relevant information for obtaining the solution to the problem. The mean score of students for the two items in this category was 47%. The Interpretation Panel rated this as Satisfactory.

The two problems in this category were of a multiple-choice format and the amount of reading required was considerable. The Panel took this factor into consideration in judging the performance of students. Caution in interpreting the results is necessary since only two items were used. One of the items was:

30) What is the best way to find out how strong a piece of string is? Check (✓) the best answer.

21% A) Measure the thickness of the string.
29% B) Find out what the string is made of.
*37% C) Lift heavier and heavier weights with the string until it breaks.
10% D) Take the string apart and soak the parts in water.

Category D17. Application of Knowledge. In this category students are required to use their scientific knowledge in solving problems and making decisions about everyday problems. The students' mean score was 37% which the Interpretation Panel rated as Satisfactory. They stated that the challenge was considerable and under the circumstances the students' achievement was acceptable.

The first item required students to determine what is best to feed a guinea pig. Nearly 70% were able to write an acceptable response. However, for the next question (#33 and #34 below) a more extensive response was required. Only 29% indicated that they should try different containers and 12% indicated that they should check to see in which container the ice melted quickest. The Interpretation Panel noted that many children did not give a complete response (44%).

33/34) You are going on a picnic. You want to pick the best container you have at home to keep your ice cream frozen? How would you find out which is best?

Summary of Results for Major Headings B. Processes of Science, and D. Problem Solving and Decision Making Grade 3. The Grade 3 results for categories under these headings were rated as Satisfactory or better by the Interpretation Panel. The mean score of students for the Processes categories was 72%, which was considerably higher than the mean score for the Problem Solving categories: 44%.

Students responded well to the items in the Processes categories, and had little difficulty with most of the items. They had some difficulty reading Celsius thermometers including negative temperatures, and interpolating to determine the amount of liquid in a measuring cup. The items in the Problem Solving categories were considered more complex by the Interpretation Panel, and the students found them more difficult. This was evidenced not only by the mean scores, but also by the high proportions of students who did not respond to some items.

Summary of the Cognitive Categories of the Test

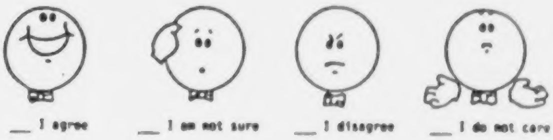
At the Grade 3 level there were 12 categories with items in the cognitive domain: six in Content of Science, four in Processes of Science, and two in Problem Solving. The students performed satisfactorily or better, as rated by the Interpretation Panel, on 11 out of the 12 categories. The exception was the category, Trends and Sequences, where performance was rated Unsatisfactory. The Panel stated that this was an important area which should be stressed more by teachers. They suggested that to gain skill in this area more discussion time should be provided at the end of units to help the children consolidate the important ideas of the unit.

Students responded at about the same rate to both formats of items, written response and multiple choice. The "No Response" rate was only slightly higher for the written response items.

E. Attitude Toward Science

The students' attitudes towards aspects of science were assessed by items which asked them to state their beliefs, attitudes, values, enjoyment, and preferences. Items in this domain were not marked as correct or incorrect. The proportions of students selecting the response options for each item are reported. For most of the questions in the area "happy faces" were provided (see example below) to assist the students in selecting the response that reflected their attitude. There are four categories under this heading: Enjoying Science, Valuing Science, Adopting Attitudes of Science, and Making Career Decisions.

39) I like to learn about science.



Category E18. Enjoying Science. The percent of students choosing each response is listed below in Table 7 for each of the five items in the category.

Table 7

Results of Grade 3. E18. Enjoying Science

Item	Percent of Students Selecting Each Response				
	I Agree	I am Not Sure	I Disagree	I do not Care	No Response
39. I like to learn about science.	74%	12%	4%	9%	1%
40. Science ideas are interesting.	73%	16%	4%	6%	1%
41. I would like to visit a scientist at work.	71%	15%	5%	9%	1%
42. I like to watch science programs on television.	55%	15%	14%	14%	1%
43. I like to read science magazines.	45%	23%	18%	14%	1%

The results reflected a very positive attitude toward science. Over 70% of the students liked to learn about science, believed science ideas are interesting, and would like to visit a scientist at work. However, their interest in science programs on television was not as high (55% agreed). Forty-five percent liked to read science magazines. The "I do not care" response increased for these last two items from a mean of 8% for items 39-40 to 14% for items 42-43.

Category E19. Valuing Science. The percent of students choosing each response is listed below in Table 8 for the four items in the category. No "happy faces" were used in this category.

Table 8

Results of Grade 3. E19. Valuing Science

	Percent of students Selecting Each Response				
Item	Very Much	A Little	Not At All	Not Sure	No Response
35. How much do you think science can help control weather?	29%	25%	11%	34%	1%
36. How much do you think science can help prevent wars?	17%	23%	25%	33%	2%
37. How much do you think science can help stop pollution	35%	28%	11%	25%	2%
38. How much do you think science can help cure sick people?	49%	20%	13%	16%	2%

The majority of students believed that science can help control weather, stop pollution, and cure sick people: approximately 54%, 63%, and 69% respectively selected "very much" or "a little" for these three aspects. Fewer students believed that science can help prevent wars -- approximately 40% selected "very much" or "a little". The greatest number of students felt that science could help cure sick people. This item also received the lowest percentage of "not sure" responses.

The Interpretation Panel was not surprised that the children expressed these views. A substantial percentage of students were "not sure" whether science could help control weather or prevent wars. As well, 25% felt that science could not help prevent wars. These appear to be reasonable responses.

Category E20. Adopting Attitudes of Science. There are three items that attempt to determine Grade 3 scientific attitudes. Although this is a fairly limited sampling of scientific attitudes it gives some indication of what Grade 3 students believe. The percent of students choosing each response is listed below in Table 9 for each of the three items.

Table 9

Results of Grade 3. E20. Adopting Attitudes of Science

	Percent of Students Selecting Each Response				
Item	I Agree	I am Not Sure	I Disagree	I do not Care	No Response
44. Doing science gives me a chance to think like a scientist.	65%	23%	6%	6%	1%
45. Even though there are many kinds of animals and plants, we should worry if a few kinds die out forever.	60%	26%	8%	6%	1%
46. Scientists always find out answers to their questions.	40%	36%	19%	4%	1%

The results reflect some very good insights into how science works and what attitudes scientists have towards science. The majority of students believed that doing science gave them a chance to think like a scientist (65%), and that it was a serious problem if species die out (60%). However, a substantial percentage of students believed that scientists always find the answers to their questions (40%). The Interpretation Panel felt that generally the children did quite well on this category.

Category E21. Making Career Decisions. The number of items in this category was limited to two. The percent of students choosing each response is listed below in Table 10 for each of the items.

Table 10

Results of Grade 3. E21. Making Career Decisions

	Percent of students Selecting Each Response				
Item	I Agree	I am Not Sure	I Disagree	I do Not Care	No Response
47. I want to work with scientists to help solve problems.	47%	27%	16%	10%	1%
48. I'd like to be a scientist.	34%	32%	26%	7%	1%

The career decision to work with a scientist or to be a scientist was not firm in the minds of very many of the children. However, it is still significant that as high as 47% wanted to work with scientists and 34% stated that they would like to be a scientist. This reflects a positive attitude towards science as a career for these young children. The Interpretation Panel considered these results to be very good.

F. Science and Society

The students' attitudes were assessed in three categories, each covering a major aspect of the role of science and scientists in society. The format of the items was similar to that used for the earlier categories. "Happy faces" were used along with the words to assist the students in selecting an appropriate response. Only one item was specified for the Energy category. For discussion it was included with the Environment category.

Category F23. Health, Nutrition and Agriculture. The percent of students choosing each response is listed in the table below for each of the three items in this category. These items attempted to probe the students' opinions and beliefs regarding issues in health, nutrition, and agriculture. The items were greatly simplified to be suitable for a Grade 3 student's understanding.

Table 10

Results of Grade 3. F23. Health, Nutrition and Agriculture

	Choice of Response				
Item	I Agree	I am Not Sure	I Disagree	I Do Not Care	No Response
49. Scientists help us grow foods that are good for us to eat.	50%	31%	14%	4%	1%
50. Too many people crowded together in cities can cause sickness.	39%	43%	13%	4%	1%
51. Too little rainfall can cause crops to die and people to go hungry.	54%	25%	18%	3%	1%

Fifty percent of students agreed with item #49 -- that scientists help us grow foods that are good for us to eat. A further 31% were not sure and 14% disagreed. It is possible that some of the children thought scientists help us grow foods that are not good for us to eat, or simply that scientists don't help. A similar problem occurs with items 50 and 51.

The Interpretation Panel felt that the wording of these items was too difficult for the students and the concepts too remote to their understanding. The rainfall item is simply stated, but there is still a large "I am not sure" response (25%), perhaps indicating their lack of understanding and involvement with the issue(s). This would be expected of grade three students who are more concerned with their immediate environment and the present.

Categories F24,25. Environment and Energy. Three of the items are about environment issues (#52, 53, and 54), and one is related to conserving energy. The percent of the students choosing each response is listed in the table below for each of the four items.

Table 12

Results of Grade 3. F24,25. Environment and Energy

Item	Percent of Students Choosing Each Option I Agree	I Am Not Sure	I Disagree	I Do Not Care	No Response
52. Saving paper, bottles, and cans is worth the time and effort it takes.	43%	35%	13%	8%	1%
53. I would like to learn more about the environment.	54%	27%	7%	11%	1%
54. I think about what my environment will be like when I grow up.	48%	37%	7%	8%	1%
55. We should use less energy so that there will be more to share with others.	63%	20%	11%	6%	1%

These items obtained students' opinions and beliefs regarding energy and the environmental issues. They were also greatly simplified so as to use appropriate vocabulary for Grade 3 students. The percent of "I am not sure" responses is fairly high, ranging from 20% to 37%. The item they are most sure of is the one dealing with "sharing" energy with others (#55).

Some of the Interpretation Panel felt that "share" was the key word that Grade 3 children would recognize and feel that they should agree with. There was some concern that the students did not have a clear understanding of the words "energy" and "environment". Some of the Panel expressed the view that many children would not be familiar with collecting paper, bottles, and cans to help conserve resources. The children's responses are interesting but it is difficult to make conclusive statements based on them except for a generally positive perspective towards sharing a useful (clean??) environment.

Summary of Results for Major Headings E. Attitude toward Science and F. Science and Society. Most of the results on the attitude section were predictable --- students expressing positive attitude towards science and science ideas and some insight into the value of science in everyday science. The items had to be simplified in the Science and Society categories to make them comprehensible to Grade 3 students. Despite simplification, the vocabulary was thought to be beyond many of the students, making it difficult to interpret the results. The percent of students selecting the "I am not sure" option was quite high for these items, suggesting that students may not have understood the issues.

Summary of the Grade 3 Written Component

The Grade 3 written component consisted of 87 items grouped under five major headings: Content of Science, Processes of Science, Problem Solving and Decision Making, Attitude Toward Science, and Science and Society. The first two headings contained cognitive items whereas the latter three contained affective items.

The three groupings of cognitive items were further divided into 12 categories. Student performance was rated as Satisfactory, or better, on 11 of the categories. Performance in two of the 11 categories was considered Very Satisfactory; these categories are in the Content of Science: #3 Concept Relationships and #4 Theories. Performance in only one category was rated as Unsatisfactory: #6 Trends and Sequences.

In summary, Grade 3 students have a good understanding of the content and processes specified for the science program.

When the items were organized under the three content themes of the curriculum guide it can be stated that the students did better on the "Interdependency and Interaction among Organisms" theme.

Student responses to the affective items cannot be as readily interpreted. However, some generalizations were made by the Interpretation Panel and the TAC. Most Grade 3 students have positive attitudes toward science and scientists. They also tend to have an appreciation for the value of science in everyday life, and an insight as to what science can accomplish. Although almost half of the students would like to help scientists in their work, a lower percentage would actually like to be a scientist.

Responses to items under the Science and Society heading indicated that students were not sure of several issues: substantial percentages of students selected the option "I am not sure" for most of the items in category 23. Health, Nutrition, and Agriculture. Students may not have understood the issues presented in the items. However, they indicated a generally positive perspective about maintaining and learning more about a "healthy" environment.

CHAPTER 3

GRADE 3 PERFORMANCE COMPONENT RESULTS

Performance testing was used to assess the level to which the students were attaining curriculum goals that are not possible to measure fully or are not adequately measured with the written test format. The Technical Advisory Committee determined the test categories which they believed should be measured using the performance component. The categories which were measured only by the performance component were: Category 12 -- Skills in Using Common Laboratory Equipment, Category 13 -- Skills associated with Safety, Category 15 -- Following Instruction and Category 16 -- Using Inquiry Techniques. Those categories which were measured by both written and performance components were: Category 5 -- Explanation of Physical Phenomena, Category 7 -- Observing and Classifying, Category 8 -- Measuring/Quantifying, Category 9 -- Identifying, Collecting, Interpreting, Reporting Data, Category 10 -- Making Inferences, Hypothesizing, and Category 14 -- Cognition.

Two different and distinct formats were used for the performance testing: the Station Approach and the Individual Approach. The Station Approach format consisted of a circuit of six stations with one student working at each station for a prescribed time (5 minutes). Each student then moved to a different station for the next time interval. This procedure continued until all six students had completed the work at each of the stations. Each station contained a sheet of simple written instructions of procedures for the students to follow, and required the students to manipulate materials and apparatus, and make written responses on the sheet of paper, thus providing evidence of their performance. A testing supervisor was present to explain the stations, monitor the performance, and collect the written responses.

The Individual Approach format tested one student at a time. The student was presented with a written task and a set of materials and apparatus. The testing supervisor clarified any concerns the student might have. The student then attempted the task. The testing supervisor carefully observed the student at work and completed a checklist which monitored the student's progress. The student also completed a work sheet. Two questions were asked of the students when they appeared to have finished. They were, "Is there anything else you would like to do in the investigation?", and "Is there anything else you would like to say about the investigation?" There were four Individual tasks. Each child did all four tasks. The time needed for each task varied from 5 to 20 minutes, with each child being given adequate time to finish the task.

The Station Test Performance Results

The station Approach format was administered to 216 Grade 3 students from a sample of English, French Immersion, and French language schools, during May and June of the 1986 school year. The six stations tested for various aspects of four of the categories under the area of Processes of Science. The categories assessed for each station were as follows:

Task

1. Blocks of Wood:	Categories	-- 8.	Measuring/Quantifying
		--10.	Making Inferences/Hypothesizing
2. Objects:	Categories	-- 7.	Observing/Classifying
3. Birds:	Categories	-- 7.	Observing/Classifying
		-- 9.	Identifying, Collecting, Interpreting, Recording, Data
4. Marbles in Tubes	Categories	-- 7.	Observing/Classifying
		-- 9.	Identifying, Collecting, Interpreting, Recording, Data
5. Boats	Categories	-- 7.	Observing/Classifying
		-- 9.	Identifying, Collecting, Interpreting, Recording, Data
		--10.	Making Inferences/Hypothesizing
6. Seeds	Categories	-- 7.	Observing/Classifying

Due to this arrangement, four categories in the Processes of Science area are assessed under more than one situation with different materials in different contexts. Table 13 presents the detailed results of the Grade 3 students' performance for the six stations. Each station's results will now be discussed separately and a summary of the results for the stations will be given.

TABLE 13

Results of Grade 3. Station Performance Approach

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
Blocks of Wood				**Students were asked to weigh 2 blocks of wood and estimate the weight of the third block.**
	1	8. Measuring	60%	Weighed to within 3 units
			16%	Weighed to within 6 units
	2	8. Measuring	74%	Weighed to within 3 units
			11%	Weighed to within 6 units
	3	8. Measuring	16%	Estimated to within 3 units
		10. Predicting	10%	Estimated to within 6 units
Objects				**Students had to place 2 objects into correct groups.**
	11	7. Observing/ Classifying	72%	Classified correctly
	12	7. Classifying	62%	Gave reason - metal
			4%	Gave reason - hard
	13.	7. Observing/ Classifying	69%	Classified correctly
	14.	7. Classifying	56%	Gave reason - wood
			24%	Gave reason - round
Birds				**Students were asked to observe 2 pictures of birds, note the differences, write what is different and how it is different.**
	21	7. Observing	35%	Stated a colour/pattern
		9. Recording Data	20%	Stated size/shape
			24%	Stated an aspect of environment
			3%	Used an inference or content clue
			3%	Stated another correct response
	22	9. Interpreting Data	75%	Gave correct reason
	23	7. Observing	23%	Stated a colour/pattern
		9. Recording Data	19%	Stated size/shape
			29%	Stated an aspect of environment
			3%	Used an inference or context clue
			4%	Stated other correct response
	24	9. Interpreting Data	68%	Gave correct reason
	25	7. Observing	15%	Stated a colour/pattern
		9. Recording Data	21%	Stated size/shape
			23%	Stated an aspect of environment
			3%	Used an inference...
			5%	Stated another correct response
	26	9. Interpreting	58%	Gave correct reason

Marbles in Tubes				**Students are asked to study marbles in tubes of 3 different liquids as they are turned upside down.** **Describe what they observe, and infer the the reason for what they observe.**
	31	7.Observing Recording Data	71%	Recorded first correct observation
	32	7.Observing 9.Recording Data	55%	Recorded second correct observation
	33	7.Observing 9.Recording Data	53%	Recorded third correct observation
	34	9.Interpreting Data	10% 42%	Gave reason - thicker liquids Gave reason - different liquids
Boats				**Students were asked to float 3 boats in a pan of tap water and note how each boat floated. Then they were asked to float 2 of the boats in salt water and predict how the 3rd boat would float, and then give their reason.**
	41	7.Observing 9.Recording Data	65%	Gave the correct response for Boat A
	42	7.Observing 9.Recording Data	59%	Gave the Correct response for Boat B
	43	7.Observing 9.Recording Data	62%	Gave the correct response for Boat C
	44	10.Predicting	11% 17% 4%	Gave the most complete response Stated that Boat B would float Stated that Boat B would float higher in the salt water
	45	9.Interpreting Data	22%	Gave good reason
Seeds				**Students were asked to divide bags of seeds into 2 groups**
	51	7.Observing/ Classifying	11% 57% 6% 5% 4%	Classified on the basis of colour or pattern, of size of shape of number of seeds of other correct aspects
	52	7.Observing/ Classifying	9% 53% 8% 4% 5%	Classified on the basis of colour or pattern, of size of shape of number of other correct aspects

Station 1. Blocks of Wood. This station dealt with the skills of using a balance. Students at this level were given on equal-arm balance and tiny blocks of wood to use as masses. Using these tiny blocks as units they were asked to weigh two blocks of wood, and then estimate the weight of a third block.

The results from Table 13 indicate that 60% were able to weigh the first (and larger) block to within 3 units and a further 16% to within 6 units. They were more accurate with the smaller block. Seventy-four percent were within 3 units and a further 11% were within 6 units.

When asked to estimate the weight of a third block, the weight of which was between that of the other two blocks, very few were able to do so accurately (16% estimated correctly to within 3 units, and a further 10% to within 6 units).

Station 2. Objects. Careful observation and classification were the skills assessed in this station. The students were given three sets of objects in plastic bags which they were asked to observe carefully. Then they were to decide the set to which two other objects would belong, and to give the reason for their choice.

A large number of the students were able to do this successfully (72% for the first object and 69% for the second object). When asked to give a reason for their choice most were able to do so correctly (62% for the first object and 56% for the second object).

Station 3. Birds. For this station students were presented with two large coloured pictures of birds. They were asked to observe the pictures carefully and notice what was different between the birds in them. For each difference they were to write down the difference and how it was different.

Most of the children were successful in this task. They were best at giving the first difference (85%), next best for the second difference (78%), and poorest for the third difference (67%). The correct reasons went down accordingly (75%, 68%, 58%).

It is noteworthy that a majority of students focussed on colour/pattern differences for their first difference, size/shape for their second difference, and an aspect of the birds' environment for their third difference.

Station 4. Marbles in Tubes. For this station students were asked to observe three tubes which each contained a marble, and a liquid of different density. They were instructed to turn the tubes upside down (they were all fastened together) as many times as they wished and write down the things they noticed. They were then to write why they thought the marbles took different amounts of time to fall to the bottom of the tubes.

Skills of observation, and recording and interpreting data were assessed in this station. A large number of students were able to correctly record their first observation (71%), but not as many their second (55%) and third observations (53%). About half were able to interpret the data and give a correct reason. Most (42%) gave as the reason that there were different liquids in the tubes.

Station 5. Boats. For this station students were requested to float three boats in the aquarium containing tap water and record what they saw about how the boats floated. The boats were made of wood of different densities. Then they were to float two of the boats in the aquarium containing salt water and observe how they floated. Using these data, they were asked to predict how the third boat would float.

About two thirds of the children were able to correctly observe and record the boats' relative floating positions. Very few were able to predict correctly how the third boat would float in salt water: 11% gave a completely correct response, 17% stated that the boat would float, and 4% responded that the boat would float higher in the salt water. Good reasons for their predictions were given by 22% of the students.

Station 6. Seeds. For this station students were asked to sort some packages of seeds into two groups and state what was the same in the groups.

Most of the students were able to do this task correctly and gave their reasons. Most of the students used size as the main sorting criterion (57% and 53%); colour or pattern were infrequently used (11% and 9%).

Summary of Station Approach Performance Results. Four categories of the Processes of Science were assessed by means of this approach. Each category except Category 8, Measuring/Quantifying was assessed in several contexts. Thus it is possible to make some generalizations of the Grade 3 students' abilities with respect to each of the processes assessed.

1. Students were successful in their observation and classification skills with scores ranging from 83% to 69% depending on the context of the task. Many were able to give correct reasons for their observation and classification tasks.

2. They were able to measure using a balance with a success rate of from 60% to 72%. However, only 16% were able to successfully estimate the weight of a block to within three units.

3. For the tasks which involved the interpretation of data, they made good attempts with the correct responses varying from 75% to 22%, depending on the context of the questions. The most difficult item was stating the basis for their prediction of the floating of the boat; the easiest question dealt with their interpretation of the data from the bird pictures.

4. The students were least successful with questions which dealt with inferring and predicting. They were required to interpret their data and predict based on that data. Success rates varied from 11% for a complete response relative to the floating ability of the third boat, to 16% as an estimation of the weight of the block.

The Individual Test Performance Results

The Individual Approach Format was administered to 142 Grade 3 students from a sample of English language, French Immersion, and French language schools, during May and June of the 1986 school year. The four tasks tested for laboratory skills by using actual apparatus for Category 12 -- Skills in Using Common laboratory Equipment, and Category 13 -- Skills associated with Safety, as well as the category in the Content of Science area, Category 5 -- Explanation of Physical Phenomena. Other areas tested in this individual format were the Processes of Science, and the Problem Solving and Decision Making areas.

The following table presents the results of the four Individual Tasks. Each set of results will be discussed separately and then a general summary will be made.

Table 14
Results of Grade 3 Individual Performance Assessment

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
Bouncing Balls				**Problem deals with finding out on which of 3 surfaces the ball bounces best.**
	61	16. Using Inquiry Techniques	5%	Controlled both variables & measured the bounce.
			10%	Had 2 of the above correct
			54%	Had 1 of the above correct
	62	7. Observing	96%	Gave correct response for wood surface.
	63	5. Explaining	80%	Gave explanation that it is the hardest surface.
			7%	Gave other correct response.
	64	9. Interpreting Data	53%	Gave response that ball bounces worst on carpet.
			41%	Said ball bounces worst on foam.
	65	14. Cognition	97%	Understood the problem
	66	8. Measuring	23%	Dropped from measured height
			47%	"Eyeballed" height
	67	12. Laboratory Skills	66%	Bounced ball carefully
	68	8. Measuring	20%	Measured height of bounce
			67%	"Eyeballed" height
	69	9. Recording Data	13%	Recorded measured height
			82%	Recorded answer
	70	16. Using Inquiry Techniques	49%	Repeated trials on all 3 surfaces
			16%	Repeated trials on less than 3 surfaces
	71	9. Interpreting Data	89%	Results consistent with data
	72	5. Explaining	78%	Correct explanation
Coloured Liquids				**Problem deals with taking the temperature of a liquid & adding drops of unknowns.**
	74	9. Recording Observations	67%	Recorded colour change - blue
			5%	Stated colour changed
			20%	Stated no change
	75	9. Recording Observations	60%	Recorded colour change - green/yellow
			12%	Stated colour changed
			21%	Stated no change
	76	8. Measuring	83%	Measured water carefully
	77	12. Laboratory Skills	93%	Poured water carefully
	78	8. Measuring	39%	Correct procedure, temperature within 2°C
			14%	Correct procedure only
			10%	Poor procedure, correct temperature
			6%	Asked how to use thermometer
	79	7. Observing	95%	Observed the changes
	80	10. Predicting	69%	Predicted using the data
	81	12. Laboratory Skills	98%	Handled equipment carefully
	82	13. Safety Skills	99%	Used safety precautions

	83	15. Following Instructions	50% 37%	Followed in correct order One step out of order
	84	9. Recording Data	93%	Recorded results
	85	16. Using Inquiry Techniques	5%	Repeated tasks after prompt
Sugar Lumps				**Problem deals with finding out if sugar lumps dissolve as quickly as ordinary loose sugar**
	91	10. Predicting	82% 12%	Predicted loose sugar Predicted sugar lumps
	92	5. Explaining	1% 28% 35%	Loose and smaller pieces Loose only Smaller pieces
	93	9. Recording Observations	62%	Recorded observations correctly
	94	9. Recording Observations	49% 38%	Observed correctly Stated no difference if water stirred
	95	8. Measuring	14% 22% 13%	Correct-controlled time Guessed at time No control, e.g. stirred both
	96	9. Observations	92%	Recorded observations
	97	15. Following Instructions	54% 12% 22%	Followed instructions Needed prompting Out of order
	98	8. Measuring	44% 23% 10%	Used equal amounts of water and of sugar Used equal amounts of water, not sugar Used equal amounts of sugar, not water
	99	9. Interpreting Data	75%	Results consistent with data
	100	12. Laboratory Skills	95%	Handled equipment carefully
	101	13. Safety	95%	Used safety precautions
	102	14. Cognition	82%	Understood the problem
	103	16. Using Inquiry	54% 8% 8%	Repeated same as first time, stirring Repeated with correct procedures this time Repeated with error
	104	8. Measuring	3%	Used balance beam correctly
Meal Worms				**Problem deals with finding out if the meal worm prefer to eat one of these foods more than others.**
	106	12. Laboratory Skills	66% 4%	Carefully handled meal worms Handled meal worms carelessly/roughly
	107	12. Laboratory Skills	63%	Used forceps to handle meal worms
	108	16. Using Inquiry Skills	68%	Used 2 or more worms
	109	8. Measuring	60%	Measured equal amounts of food

110	8. Measuring	73%	Placed worms at same distances away from food
111	8. Measuring	2% 32%	Timed eating carefully, using a clock Timed approximately
112	7. Observing	44%	Observed, using the hand lens correctly
113	9. Interpreting Data	85% 1%	Inferred correctly from data Used incomplete data
114	12. Recording Data	76%	Recorded data accurately
115	12. Laboratory Skills	91%	Handled equipment carefully
116	14. Cognition	85%	Understood the problem

Individual Task 1. Bouncing Balls. This task asked the students to determine on which surface a ball bounced best. They were asked to describe their method, tell on which surface the ball bounced best and why, and then state on which surface the ball bounced worst. They were supplied with three different surfaces, a ball, and a yardstick. The students had to decide how to carry out the investigation and report their results without any assistance from the tester. Most children tackled the task eagerly. The results were:

1. Nearly all the children (96%) made accurate observations.

2. Few children (23%) dropped the ball from a measured height; forty-seven percent "eye-balled" the height. The remainder did not do either.

3. Few children (20%) measured the height of the bounce; two-thirds "eye-balled" the height of bounce. The remainder did neither.

4. Nearly all (89%) had results consistent with their data for the best bouncing surface. However, they were divided as to on which surface the ball bounced worst -- 53% said the carpet, and 41% stated the foam. Clearly it was difficult to make the distinction.

5. Two thirds of the students bounced the ball carefully.

6. Nearly all the children (97%) seemed to clearly understand the problem.

7. With respect to using inquiry techniques, only 5% controlled both variables (different surfaces and height of drop of the ball) and measured the height of the bounce; ten percent had two of the above correct. Nearly half repeated their trials on all three surfaces, and 16% repeated trials on less than 3 surfaces.

Individual Task 2. Coloured Liquids. For this task the students had to follow directions in taking the temperature of water, and adding various drops of liquid to the beaker. Students were required to make careful observations and to carefully follow instructions and record results. A summary of the children's abilities as measured by this task is:

1. Observing skills were very satisfactory and the majority of children recorded their observations.

2. Most (83%) measured the water correctly, but fewer (39%) were able to take the temperature correctly.

3. About 2/3 were able to predict using the data they had gathered.

4. Nearly all poured the water carefully, and handled the equipment carefully.

5. Half followed the instructions through all the steps. Thirty-seven percent had one step out of order.

6. With respect to the use of inquiry techniques only 5% repeated their trials even after a prompt.

Individual Task 3. Sugar Lumps. For this task the students were given the problem "Find out if the sugar lumps dissolve as quickly as the ordinary loose sugar". They were asked to predict, explain their prediction, and then carry out the investigation. Then they were asked to repeat the investigation. The following results were obtained:

1. Most of the children were able to make predictions, but few were able to give good reasons for their predictions. Only 1% gave a complete response, whereas 63% gave partially correct answers.

2. Measurement was an important part of this task but only 44% used equal amounts of water and of sugar; few used equal amounts of water, not sugar; and 10% used equal amounts of sugar, but not water. Only 14% controlled the time of stirring for both types of sugar; twenty-two percent guessed at the time. The remainder did not seem to consider this factor.

3. Most of the children recorded their observations correctly as in some cases the water did not change colour.

4. For 75% of the children their results were consistent with their data.

5. Nearly all the students handled the equipment correctly and safely.

6. Most of the students (82%) seemed to understand the problem, and 54% repeated their trials as per the instructions on the sheet.

Individual Task 4. Meal Worms. This task was very open-ended. The students were given the problem of finding out if meal worms preferred to eat one of the given foods more than others. They had to record their procedures and come to a conclusion. The results were:

1. All of the students were interested in this task, with 44% using the magnifying glass to observe the meal worms.
2. Most of the students (85%) seemed to understand the problem. Measurement was a critical factor: sixty percent measured equal amounts of food, 73% placed the worms at equal distances from the food, but only 2% timed the eating accurately (32% did an approximation).
3. Many (76%) recorded their data accurately, and 85% inferred correctly from their data.
4. Many of the children were reluctant to pick up the meal worms, with 63% using forceps. Two thirds handled the worms carefully. The equipment was handled carefully by 91% of the students.
5. As to their ability to set up the experimental procedure, over two thirds (68%) showed some evidence of this by using more than two worms and, as noted above, placing the worms at equal distances from the food, and measuring equal amounts of food.

Summary of Grade 3 Performance Component

The Grade 3 Performance component consisted of six Station Format tasks and four Individual Format tasks. The performance component was specifically used to assess certain categories within the assessment framework which are not possible or very difficult to assess by written tests, and to supplement the information gained from the written test for several other categories.

Four categories were assessed only by the performance test. The category related to using laboratory equipment was assessed by the Individual Approach Format where the testing supervisor watched the children at work and recorded their activities. Two thirds of the children bounced the ball carefully, whereas nearly all the children handled the laboratory equipment carefully and safely. About half of the students followed the instructions carefully when they were written out in detail. In some cases they were free to design their own procedures. The use of Inquiry Techniques varied according to task.

Six categories were assessed by both Written and Performance components. Individual testing was used for the category relating to explanations of physical phenomena. For the two tasks in which explanations were asked, the students were moderately successful depending on the context.

Categories which involved the processes of science were extensively tested using both formats. The students were very good at making and recording observations and at classification. Many aspects of measurement were assessed with results varying as follows:

- About 2/3 are able to use a balance
- About 1/3 are able to take the temperature of a liquid
- About 5/6 are able to measure liquid into a beaker

In the **Bouncing Ball** investigation -
  - about 1/4 dropped the ball from the same height each time
  - about 1/5 measured the height of the bounce

In the **Sugar Lumps** investigation -
  - less than 1/2 used equal amounts of water and sugar
  - very few (14%) used equal time intervals

In the **Meal Worms** investigation -
  - more than 1/2 used equal amounts of food
  - more than 2/3 placed the worms at equal distances from the food
  - almost none (2%) used equal time intervals for eating

Their ability to interpret data varied according to the context of the task. Inferences and predictions were poorly done in the station tasks and better done for the individual tasks where the situations were probably more familiar (Water, Sugar Lumps), suggesting that the context is an important element to consider when measuring achievement.

The children tackled all the tasks with much enthusiasm and nearly all seemed to understand the problems presented.

The area which evidenced the most weaknesses was that of using inquiry techniques. Almost none were able to control variables in the Bouncing Ball task, but 1/2 repeated their trials. For the Coloured Liquids almost none repeated the task even after verbal prompting. For Sugar Lumps, 2/3 repeated the task as instructed on the sheet. For the Meal Worms most did several trials using more than one worm, and as noted above, a good proportion controlled for both amount of food and distance.

Recommendations Based on the Grade 3 Written and Performance Component

Generally the written test results indicated that students understood the content and processes of science expected of them at the Grade 3 level. Students performed particularly well on the questions concerning scientific concepts and on questions related to identifying and interpreting data.

The Interpretation Panel noted one particular area of concern: students had difficulty understanding and explaining "how people can help stop animals and plants from becoming extinct".

Although student performance on the whole was satisfactory, several concerns were identified. Students often had difficulty providing a complete and precise written response. Often students could give one response to an item, but had more difficulty giving a second answer when more than one was requested.

> **Recommendation**. The TAC recommended that students be given more practice in working with problem situations. They should be given ample opportunity to discuss what they are doing and to explain what they thought was happening. They should be encouraged to use correct scientific terminology, and to develop written answers to problems.

Students had little difficulty answering the process items on the test, and generally did well. Several items did pose some difficulty: many students could not correctly read a Celsius thermometer that included negative temperature markings (32% of students chose -21° Celsius when 21° was correct). Also, one-third of the students could not interpolate to determine which measuring cup contained 125 mL when the cups were marked in 100 mL increments. The skills required in the items above are complex but it was expected that students would be familiar with these measuring devices.

> **Recommendation**. The TAC was impressed with students' skills in the processes of science, but recommended that students be given continuing practice in reading and using everyday measuring tools: thermometers, measuring cups, scales, etc. Weaknesses tended to be in the area of estimating results. Students should be given experiences collecting and tabulating data, on such things as room and outdoor temperature, precipitation, etc. This would give them practice in using measuring tools as well as clearer notions of room temperatures and common weather facts.

Student mean scores for categories of Problem Solving and Decision Making were lower than for most other categories in the test: the mean percent correct was 47% and 37% for Cognition and Application respectively. These are difficult aspects of science for students at the Grade 3 level.

Recommendation. More emphasis should be placed on problem solving in science, particularly in applying scientific knowledge to solving everyday problems in attempting to define a problem and what constitutes a fair test.

In the affective domain student responses indicated generally positive attitudes to science. Students seemed less positive to reading about science or watching science programs on television. The TAC was concerned that students may not know which magazines or television programs are scientific in nature, or have scientific content.

Recommendation. Students should be aware of materials that present scientific information appropriate to their grade level, including science magazines and science television programs. Schools should ensure that students have ample opportunity to use science written and/or audio/visual science materials.

Student responses to the affective items in the Valuing Science and Adopting Attitudes of Science categories indicate that they seem to have some idea of the impact of science in their lives. However, the TAC felt that they may not know both positive and negative aspects and impacts of science.

Recommendation. Students should be provided with examples of how science and technology have an impact on their lives from the simple, such as fire, to the more complex, such as preventing the extinction of some animal species. Maintaining a positive attitude and using discussions about how individuals can maintain a healthy environment should be a part of the science program.

In the Science and Society heading many students were unsure of what they felt or believed although they appeared to have a positive attitude towards their natural and man-made environment.

Students were fairly certain that we should use less energy and share it with others (63% agreed) but were less sure of things like saving paper, bottles, and cans (43%).

Recommendation. Students should be made aware of the benefits of saving and recycling such things as paper, etc. More time should be spent on topics dealing with science and society: such things as class discussions could be used.

For the Performance categories deficiences in science processes and inquiry techniques have already been noted.

Recommendations. (a) Students should be given more practical experiences in which they have to interpret data, infer, predict and explain physical phenomena. They also need open-ended problems for which they have to learn to design "fair tests".

(b) Students should be given more real objects and experiences to work from and more real problems to solve. Measuring should be much more strongly integrated with practical activities.

CHAPTER 4

GRADE 6 WRITTEN TEST RESULTS

This chapter reports the Grade 6 written test results. The tables present the categories under each major heading assessed and include the item numbers, the total number of items, the mean raw score, the standard deviation, the mean percent correct, and the rating given by the Interpretation Panel for the category. Each category is then summarized and sample item(s) are sometimes presented to illustrate performance in that category.

A. Content of Science

The assessment of the students' acquisition of science content through the Grade 6 level is accomplished by a hierarchy of cognitive structures beginning with knowledge of facts and terminology, proceeding through theories and conceptual schemes and concepts/relationships, explaining physical phenomena, and ending with trends and sequences. The latter categories require higher level thinking, and analysis and synthesis processes. The results are summarized in Table 15.

Table 15

Results of Grade 6. A. Content of Science

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
1. Facts	24-36	13	8	2.38	62%	Satisfactory
2. Terminology	37-45	9	4	2.11	49%	Marginal
3. Concepts	46-55	10	7	2.25	68%	Satisfactory
4. Theories	56-60	5	2	1.22	35%	Unsatisfactory
5. Explanation	61-63	3	2	0.94	52%	Marginal
6. Trends	64-66	3	1	1.04	48%	Marginal
Total Content Area		43	24	6.9	56%	*

* No summary interpretation by the Interpretation Panel.

Content A1. Facts. Science Assessment facts for Grade 6 were defined in accordance with Bloom's cognitive level of knowledge. This category is at the recall level. Students obtained a mean score of 61% on their knowledge of facts. The Interpretation Panel rated this as Satisfactory.

More than half of the questions were of the written response format in which the students were asked to recall reasons why two animals had become extinct, to name a type of electricity, to name a type of adaptation, and to state the activities in a food chain. On the average 9% of the students did not respond to these questions. This was twice as high as the mean No Response rate for the multiple choice format questions.

Less than half of the items had illustrations to supplement the text. Items with accompanying illustrations had an 8% higher mean score. The question which the children found most difficult, is given below. This item had a mean score of 36%.

26) Why do we have the warmest weather in summer?

*36% A) Sun's rays are more vertical in summer than in winter.
3% B) The winds are warmer in the summer.
1% C) The air is freer of clouds in the summer.
57% D) The Sun is nearest to Earth in summer and farthest away in winter.

Category A2. Terminology. Terminology, according to Bloom's Taxonomy, is defined as comprehension. The questions in this category generally ask for some elaboration of fact. The mean score for this category was 49%. The Interpretation Panel rated this as Marginal.

Students had difficulty recalling the scientific names or terms for the descriptions given and/or explaining their meaning. They were most successful (71%) at naming the remains of plants or animals in sedimentary rocks (fossils), and least successful at defining a consumer from a given description (30%). For the three written response items, 16% of the students gave no response. This was over twice as high a "No Response" rate as for the multiple choice items. A typical multiple choice item was #43 for which the mean success rate was 60% for this item.

43) Rain and water can wash away soil. What is this called?

***60% A) erosion**
11% B) water cycle
11% C) evaporation
14% D) weathering

Category A3. Concepts/Relationships. A concept has been defined as the nucleus about which knowledge is organized. For example, the knowledge of erosion relates to the movement of Earth's materials by forces such as wind and water. Concepts and relationships may be thought of as being above Bloom's cognitive level of comprehension. Grade 6 students received their highest mean score (68%) for this category under the Content heading. This was judged as Satisfactory by the Interpretation Panel.

This category consisted of three written response items and six multiple choice items. For the written response items almost twice as many students did not respond compared to the multiple choice items (9% compared to 5%). The question topics were from the three content themes. The correct responses varied with a mean of 47%.

In keeping with the Grade 3 results, Grade 6 children frequently had trouble giving a second response to a question. The "no response" response rate doubled for the second response on the following question.

46/47)

Some carnivores have sharp teeth for tearing flesh. Name two other adaptations carnivores may have to help them hunt.

Category A4. Theories and Conceptual Schemes. Theories in science may be thought of as research-supported explanations of physical or natural phenomena. A conceptual scheme is an ordering of concepts according to a particular logic. For a student to be able to discuss theories and conceptual schemes he/she has to be operating at Bloom's higher cognitive levels of thinking.

Grade 6 students scored 35% in this category which consisted of two basic questions with several parts each. One dealt with electromagnets, and the other with sedimentary rocks and fossils. Both were difficult for the students and the results were rated Unsatisfactory by the Interpretation Panel. They noted that the questions were poorly done, and that perhaps the electromagnet one was too conceptually difficult for Grade 6 children. They also suggested that the Earth Science question may have only been touched on at Grade 5 and the unit did not focus on the concepts in the question.

Category A5. Explanation of Physical Phenomena. This category is broader than formulating a theory or conceptual scheme. Some explanations may involve several theories or conceptual schemes and involve higher level thinking skills. This category consisted of three items - one for each conceptual theme in the curriculum. The mean success rate of the students was 52%. The Interpretation Panel considered this to be Marginal.

The students performed best on the two multiple choice items and poorest on the item for which a response had to be written. Nearly 9% did not respond to the latter item as compared to 5% for the former. The student's mean success rate was highest (65%) on the question from the theme, Interdependency and Interaction among Organisms:

62) A female red squirrel only lets other red squirrels into her territory in early spring. Which statement best explains her behaviour?
8% A) Early spring is when squirrels come out of hibernation.
4% B) Male squirrels are good at finding food in the spring.
*65% C) Females let males into their territory in the spring in order to mate.
18% D) It is safer for squirrels to be in groups after the winter.

Category A6. Trends and Sequences. This category identifies the students' knowledge of science as it relates to common trends occurring in today's technological society. The questions dealt with non-renewable natural resources -- a topic studied to some extent in the Grade 6 Interdependency and Interaction units. The mean success rate for the category was 48%. The Interpretation Panel rated this category as Marginal.

The items in this category all required written responses and the "No Response" rate was very high, varying from 11% to 30%. The children did, however, succeed fairly well when they attempted a response -- with the highest success rate being 59%. A possible reason for the lowered response rate could have been due to the fact that these questions were at the end of Part 1 of the test.

SUMMARY OF A. CONTENT OF SCIENCE GRADE 6

In reviewing the results of the Grade 6 content test the students generally did better on the categories in the lower levels of Bloom's Taxonomy and more poorly on the higher cognitive level categories, especially on: Theories and Conceptual Schemes, Explanation of Physical Phenomena, and Trends and Sequences. The students' mean score on the latter three categories was 45%. Even the terminology category had a percent success rate of less than 50. The only two categories rated as Satisfactory by the Interpretation Panel were 1. Facts and 3. Concepts/Relationships. The mean score for the whole content area was 56% as compared with the mean percent for all the cognitive subtests which was 57%.

Grade 6 students varied in their ability to respond to the different formats of items. They failed to answer about twice as many of the written response type items compared to the multiple-choice items. They also had difficulty giving a second response or reason for an item if required to do so.

RESULTS OF THE ASSESSMENT GROUPED BY CONTENT THEMES

The Manitoba K-6 Science curriculum guide is structured throughout the grades by means of three content themes -- Interdependency and Interaction among Organisms, Changes in Matter and Energy, and Earth, Space and Time. The 43 items in the major heading A. Content of Science are listed under these themes and the mean success levels tabulated. The themes and category breakdowns are given in the following table.

Table 16
Results of Grade 6. Content Themes

Theme	Category	No. of Items	Percent	Panel Rating
Interdependency and Interaction among Organisms	1. Facts	8	69%	
	2. Terminology	1	30%	
	3. Concepts	7	68%	
	5. Explanations	1	65%	
	6. Trends	3	48%	
Total Theme		**20**	**63%**	**Satisfactory**
Changes in Matter and Energy	1. Facts	2	48%	
	2. Terminology	5	48%	
	3. Concepts	2	68%	
	4. Theories	3	63%	
	5. Explanations	1	40%	
Total Theme		**13**	**50%**	**Marginal**
Earth/Space/Time	1. Facts	3	52%	
	2. Terminology	3	58%	
	3. Concepts	1	65%	
	4. Theories	2	48%	
	5. Explanations	1	52%	
Total Theme		**10**	**49%**	**Unsatisfactory**

When the items in the content area have been divided according to the themes, it is found that 20 are in the Interdependency and Interaction theme, 13 in the Changes in Matter and Energy theme, and 10 in the Earth/Space/Time theme. The mean score in the Biological theme is significantly higher than in the other two themes. The scores for the other two themes were rated by the Interpretation Panel as less than Satisfactory.

B. Processes of Science

The assessment of the students' ability to perform in the processes of science was accomplished through questions dealing with a hierarchy of process skills beginning with the basic processes of observing, measuring, identifying and collecting data, to the more complex processes of interpreting data, inferring and hypothesizing. The highest cognitive level was tested by questions on model making. There was a total of 34 items in two formats, multiple choice and written response. Results are summarized in Table 17.

Table 17
Results of Grade 6. B. Processes of Science

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
7. Observing	67-71	5	4	1.30	70%	Very Satisfactory
8. Measuring	72-75	4	2	1.17	62%	Satisfactory
9. Identifying	76-86	11	6	3.15	57%	Marginal
10. Making Inferences/Hypothesizing	87-96	10	7	2.29	68%	Satisfactory
11. Models	97-100	4	2	1.08	45%	Marginal
Whole Process Area		**34**	**21**	**6.55**	**61%**	**

** No summary interpretation by the Interpretation Panel.

Category B7. Observing/Classifying. In this category students observe features of their environment by using the appropriate senses. As a result of their knowledge and past experiences they interpret their observations. Classification of objects is possible after careful observations noting similarities and differences. All the questions on observing had pictures as well as text to aid in the responses.

The mean correct responses varied from a high of 85% to a low of 44%. The question with the lowest score (#69) was used in the grade 3 test. The grade 3 students received an 8% higher score than the Grade 6 students for this one item. The question directed the children to observe the picture of the apple tree and tell what they could be sure was true. More children at the Grade 6 level inferred rather than observed only, as directed. The other items in this category were done fairly well and the category was judged by the Interpretation Panel to be Very Satisfactory.

Category B8. Measuring/Quantifying. This category consisted of items dealing with measuring skills. The questions asked the children to estimate the height of a hill in the picture, read the length of a piece of wood from a scale, show their skill in reading the amount of liquid in a measuring cup, and to respond to a multiple choice item on finding the average weight of 11-year-olds. The children did poorest on reading the length of a piece of wood (They were expected to put in the cm notation). The Interpretation Panel gave the category an overall rating of Satisfactory.

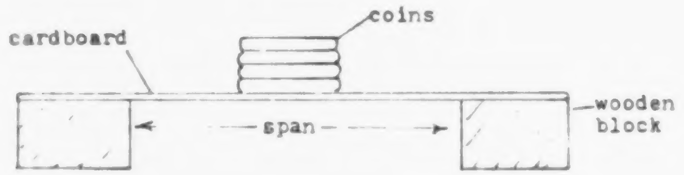
Category B9. Identifying, Collecting, Interpreting, Reporting Data. Data sources must be identified so that the relevant data will be collected and in order to determine which data are unnecessary. The relevant variables must be controlled if the responding variable is to be measured. The data are then organized, tabulated, and reported in light of the problem. The students' mean success rate on this category was 57% and was rated as Marginal by the Interpretation Panel.

The students did poorly particularly when it came to drawing and labelling a graph correctly. Sixty-four percent were able to extrapolate and interpolate on given graphs, pick the correct graph to fit a chart of data, and plot data on a chart. However, when it came to actual graph making their success rates on labelling and marking variables, choosing a reasonable size scale, and drawing the bars correctly was at or below 50%.

Category B10. Making Inferences/Hypothesizing. Data interpretation leads to inference making and prediction. After several investigations have been completed it may be possible to suggest a hypothesis about the problem. This category included items on predicting and hypothesizing. The two questions on hypothesizing had the lowest success rate. This might be expected because hypothesizing is a higher level process skill than predicting. The overall success rate for the category was 68% which was judged as Satisfactory by the Interpretation Panel.

For the question printed below, 21% of the children did not respond to the first part where they were asked to find a pattern in the data. The second part of the question asked students to predict the outcome and a greater percentage of students responded.

Alan made a model bridge out of two blocks of wood and a piece of cardboard.



He measured the span in centimeters and counted the number of 25c coins which the bridge could support without bending.

Span (cm)	Number of 25c coins
10	5
12	4
14	3
16	2
18	1

What pattern do you notice between the span and the number of 25c coins the bridge could support?

92) The pattern I notice is ______________________________.

93) How many 25c coins do you think the bridge would support when the span is 8cm? _______ coins

Category B11. Building, Testing, and Revising Theoretical Models. In this category models are devised to fit the scientific data and concepts which have been developed. Several concepts were listed and the students were asked to match the appropriate models with them. The four items had a mean score of 45% and this was judged by the Interpretation Panel as Marginal.

The students were best able to match up the "sun-earth relationship" model (79%) and least able to match up the "action-reaction" model (17%). The Panel felt that there was more than one possible response (A,C,E) to item 98.

We often use models to help explain things in science that we cannot use our senses to observe. For example - light reflects from a mirror much like a basketball bouncing from a backboard.

Match each of the following concepts on the left with a model that has been developed to help us understand the concept. Put the letter of correct answer in the space provided.

(97)	_____	population interactions	A) stone dropping in pool of water
(98)	_____	action-reaction	B) food web
(99)	_____	sound	C) rocket launching
(100)	_____	sun-earth relationship	D) flashlight and globe
			E) hitting a row of marbles

D. Problem Solving and Decision Making

For the assessment of the students' ability to do problem solving and decision making they were presented with word situations or problems for which they would have to identify the problem or apply scientific knowledge to suggest a possible solution to the problem. In all cases real life situations were selected which students would not have encountered in their science program. Three categories were assessed under this heading: Cognition of a Problem, Using Inquiry Techniques, and the Application of Knowledge in science to solve problems and make decisions. The results are summarized in Table 18.

Table 18

Results of Grade 6. D. Problem Solving and Decision Making

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
14. Cognition	101-103	3	2	0.87	58%	Satisfactory
16.Using Inquiry Techniques	104-110	7	4	1.83	52%	Satisfactory
17. Application	111-113	3	1	0.83	30%	Unsatisfactory
Total Problem Solving		**13**	**6**	**2.70**	**48%**	*

* No summary interpretation by the Interpretation Panel.

Category D14. Cognition. This category deals with the perception of a problem as a problem. This perception would also include the ability to select relevant information for obtaining the solution to the problem. The average success rate for students in this category consisting of three questions was 58% and the Interpretation Panel rated this as Satisfactory.

The three problems in this category had a multiple choice format with four possible responses each. The scores ranged from 25% to 76% correct. The item which the students had the most difficulty with is included below. Many seemed unable to reason it through and more selected B) as an answer (40%) than the correct answer A) (25%).

101) A student predicted that 200 mL of water should dissolve more than 10 g of salt. What would be the best way to test this prediction.

***25% A) Add 10 g of salt to 200 mL of water. Then add a little bit more salt to see if it dissolves.**

40% B) Add 10 g of salt to 200 mL of water and see if all the salt dissolves.

9% C) Add 25 g of salt to 200 mL of water and see if any salt remains undissolved.

21% D) Add small amounts of water to 10 g of salt and see how much water it takes to dissolve all the salt.

Category D16. Inquiry Techniques. These techniques require a student to perceive a problem and propose a solution according to experimental procedures in science. This category contained four major questions, some with more than one response required. There was one multiple-choice item and the rest were written responses. The achievement level for the area was 52% which the Interpretation Panel rated as Satisfactory.

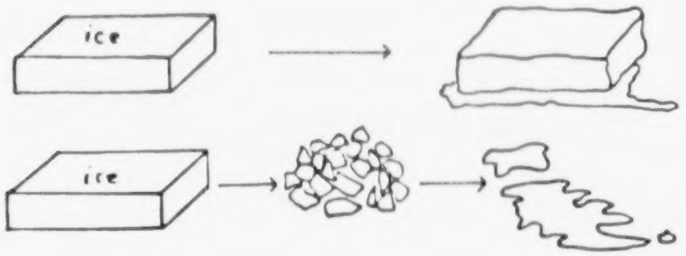
The students' mean score for the multiple choice item was 77%, but for the written response questions it was as low as 12%. This 12% score was in a three-part question in which the children were to outline an experimental procedure. Many of the students did not respond to this 3rd part (74%). Even the "No Response" rate for the 2nd part of the question was very high (55%). This was the question in which the students were asked to design their experimental procedures.

Category D17. Application of Knowledge. In this category students use their scientific knowledge to help solve problems and make decisions about everyday problems. There were two questions in this category, one with two parts. Both were practical problems with a written response format. The students' mean success rate was 30% and the Interpretation Panel rated this as Unsatisfactory although they realized this judgement was based on two questions.

The achievement for the first item (#111), about dissolving of salt in solution was low (50%); the achievement for the other question (see #112, 113 below) was even lower: 26% and 14% respectively. Many students were unable to give a second reason. The percent of students who failed to respond to the second part rose from 6% to 22%.

112/113 Joy wanted to find out the best way to keep ice frozen for a picnic. To help find the answer she did the following experiment.

Two blocks of ice the same size were taken out of the freezer at the same time. One was left in a block and the other was crushed up.



The crushed ice melted more quickly than the block.

Why do you think this happened? Give two reasons.

Summary of B. Processes of Science, and D. Problem Solving and Decision Making Grade 6. In reviewing the assessment results for these two areas it is noted that the results vary from Very Satisfactory to Unsatisfactory. Students generally performed well in observing, measuring, inference making, cognition of problems, and using inquiry techniques, marginally on identifying, collecting, reporting data, building, testing, revising theoretical models, and unsatisfactorily on applying knowledge of science to solve problems.

E. Attitude Toward Science (Cognitive Items)

The assessment of students' attitudes towards aspects of science was accomplished by sets of items to which they were asked to state their beliefs with respect to science. Some of the items in this area measured a cognitive aspect, that of knowing what activities certain professionals do in their careers. This was part of category E21. Making Career Decisions. These results are reported below in table 19.

Table 19

Results of the Cognitive Items in E21. Making Career Decisions

Category	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
21. Making Career Decisions	19-23	5	4	1.30	83%	Very Satisfactory

For the five items in this part of the category the students were asked to match the names of careers with a description of what a person in that career does. They did very well matching up veterinarian (94%), astronomer (85%), agricultural consultant (71%), geologist (72%), and pharmacist (91%) with the correct description. The Interpretation Panel rated this as Very Satisfactory.

E. Attitude Toward Science (Affective Items)

The assessment of students' attitudes towards aspects of science was accomplished by sets of items to which they were asked to state their beliefs, attitudes, values, enjoyment, and preferences with respect to science. Items were not marked correct or incorrect; the proportions of students selecting the response options for each item are reported. For some of the items in this area "happy faces" along with words were used to assist the students in selecting the appropriate response. There are four categories in this area. Enjoying Science, Valuing Science, Adopting Attitudes of Science, and Making Career Decisions.

Category E18. Enjoying Science. The questions with the percentages of students choosing each response is listed below in Table 20 for each of the five items in the category.

Table 20

Results of Grade 6. E18. Enjoying Science

	Choice of Response				
Item	Agree	Not Sure	Disagree	Don't Care	No Response
1. I like to learn about science.	61%	19%	7%	11%	2%
2. Science ideas are interesting.	74%	17%	4%	4%	2%
3. I would like to visit a scientist at work.	66%	17%	5%	10%	2%
4. I like to watch science programs on television.	37%	20%	24%	17%	2%
5. I like to read science magazines.	30%	22%	28%	18%	2%

The results reflect a positive attitude toward science, particularly with regard to learning about science, science ideas, and visiting a scientist at work. However, their interest in science programs on television and in reading science magazines is low -- 37% and 30% respectively. The "I do not care" responses for these last two items are nearly 20%.

Category E19 Valuing Science. The percent of students responding to the "happy face" items 6-9 is listed below in Table 21. The percent of students for items 10-13 in the other response format (very much, a little, not at all, not sure) is given in Table 22.

Table 21
Results of Grade 6. E19. Valuing Science
Choice of Response

Item	Agree	Not Sure	Disagree	Don't Care	No Response
6. Scientists create more problems than they can solve.	28%	41%	30%	3%	2%
7. Ideas from science are too difficult for most people to understand.	34%	35%	27%	2%	2%
8. Most of what I learn in science classes is useful in everyday life.	58%	23%	15%	2%	2%
9. Most of what I learn in Science classes will be useful in the future.	68%	23%	4%	3%	2%

The results show that the students were very unsure of the first two items. The "disagree" response was higher than the "agree" for item 6. For item 7 the "agree" was slightly higher than the "disagree", but lower than the "I am not sure". For items 8 and 9, the students scored 58% and 68% respectively on the "Agree". The students answered all items thoughtfully, the "I do not care" rate and the "no response" rate were very low for all items.

Table 22
Results of Grade 6 E19. Valuing Science
Choice of Response

Item	Very much	A little	Not at all	Not sure	No response
10. How much do you think science can help control weather?	22%	36%	18%	21%	2%
11. How much do you think science can help prevent wars?	12%	32%	30%	24%	3%
12. How much do you think science can stop pollution?	42%	35%	9%	12%	2%
13. How much do you think science can help cure sick people?	65%	20%	4%	8%	2%

The responses indicate that the students had difficulty in responding to the first two questions. A total of 58% stated "very much" or "a little" to whether science can help control weather, and less than 45% stated "very much" or "a little" to whether science can help prevent wars. Thirty percent responded "not at all" to this question. For the last two items (#12, #13), students were more positive about the value of science in helping stop pollution and curing sick people.

The Interpretation Panel felt that the attitudes and values expressed in responding to the questions in this category were well thought out and reasonable.

Category E20. Adopting Attitudes of Science. This category consists of three items, two which are multiple choice, and one whose response choices range through "agree", "undecided", to "disagree". There are no right answers, just reflections of students' attitudes towards science. Each item will be reproduced and the response discussed.

14) Someone said that if you mix 2 grams of salt and 100 grams of sugar with 1 litre of water and let the mixture stand, you get salt-water taffy, a kind of candy. The best way for you to test this would be to:

11% A) search for the recipe in an encyclopedia.
6% B) buy some salt-water taffy and see if it has salt in it.
71% C) mix the salt, sugar and water, let them stand, and observe what happens.
11% D) dissolve taffy in water and boil away the water to see if sugar and salt are left.

The responses for this item suggest that a large majority of the students (71%) believe that you should try things out rather than search for the recipe in an encyclopedia. They had read the question carefully and picked the response which suggested that they should follow the recipe given and note the results.

15) You are walking in the woods and happen to see a clover plant that has one four-leaf stem among many three-leaf stems. What can you say about this observation?

30% A) You will be lucky.
50% B) Some clover plant stems have four leaves.
2% C) Nature has made a mistake.
8% D) Something must have split the leaf.
8% E) The plant can't be clover.

The students' responses indicate that 50% have a belief in the truth of careful observation and reporting of things as you see them. However, 30% of them indicated a belief in superstition.

16) If pollution of the environment continues to increase, then I should be concerned that many living things will become extinct.

78% A) Agree
15% B) Undecided
5% C) Disagree

The responses indicate a strong belief that living things will become extinct if pollution of the environment continues to increase.

Category E21. Making Career Decisions. The results of the cognitive items in this category have already been reported in Table 19. For the two affective items the percent of students choosing each response is listed below for the 2 items in this category and the questions themselves are given.

Table 23
Results of Grade 6. E21. Making Career Decisions
Choice of Response

Item	Agree	Not Sure	Disagree	No Response
17. I would like to work with scientists in an effort to solve problems.	44%	14%	39%	2%
18. I think that there are science-related jobs that I may want to learn to do.	52%	12%	33%	2%

The responses for the items in this category indicate that less than half agreed they'd like to work with scientists and slightly more than half think there are science related jobs that they may want to do. There is a large number who disagree (33% and 39%) although a fairly low "not sure" response. The Interpretation Panel stated that the responses reflected a positive attitude toward science.

Summary of E. Attitude toward Science

There were four categories in this area. For this affective domain it cannot be said that the students did well or poorly as we were attempting to measure their attitudes, opinions, preferences, and enjoyment with respect to science. In interpreting their responses it seems that they enjoy learning about science and science ideas, but would rather participate in science activities than be told about science through television or magazines. They are not sure whether scientists create more problems they can solve, but they believe the science they learn in class will be useful to them in everyday life and in the future. They are not too definite about the value of science in controlling weather, wars, and pollution, but believe that science can help cure sick people. About half of the children may be interested in a science related career and less than half want to work with scientists in an effort to help solve problems.

F. Science and Society

The assessment of students' knowledge relative to certain topics of science and society was undertaken by asking them questions requiring comments or reasons in the form of written responses. Three categories in this area were tested at the Grade 6 level: F23. Health, Nutrition, and Agriculture, F24. Environment, F25. Energy, and the results are summarized in Table 24.

Table 24
Results of Grade 6. F. Science and Society

	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel
23. Health	114-117	4	2	1.21	57%	Marginal
24. Environment	118-121	4	2	1.18	42%	Marginal
24. Energy	122-123	2	1	0.75	35%	Unsatisfactory
Total Science & Society Area		**10**	5	2.47	**46%**	*

* No summary interpretation by Interpretation Panel.

Category F23. Health, Nutrition and Agriculture. For the purpose of this Grade 6 assessment knowledge, concerns, or problems in this general area where they are related to mankind and survival are considered in this category. There were two questions, each with two responses. The students' mean score was 57% . The Interpretation Panel rated this as Marginal.

Both of the questions dealt with food and agriculture, one concerning chemical fertilizers and sprays, and the other with inventions which have improved farming. The Panel noted that for each question many of the students were only able to write one of the two reasons correctly. The Interpretation Panel stated that the students should be able to do better. Some of the students did not try a second response, 21% and 26% respectively.

Categories F24. Environment. This category includes conservation of resources, renewable resources, pollution, acid rain, and so forth. There were two questions in this category, each requiring two responses. The students' mean score was 42% which the Interpretive Panel rated as Marginal.

Both of the questions dealt with environmental issues: chemical sprays (pros and cons) and water quality. The students had low scores on the water quality question (31% and 23% respectively). The Panel stated that with recent media attention to these issues it was surprising that the results were so poor.

Category F25. Energy. The major topics in this category were sources, uses, and conservation of energy. There was only one question in this topic; it required two responses. The students mean score was 35%. The Interpretation Panel rated this as Unsatisfactory but cautioned that generalizations should not be made on the basis of two items.

The question dealt with the major effects that energy development has on our lives. Nearly 25% did not attempt to respond, those that did scored 40% for stating the good effects, and 29% for stating the bad effects.

G. Nature of Science

The assessment of the Grade 6 students' knowledge of the nature science was limited to one category G27. History of Science. The results are tabulated in Table 25.

Table 25

Results of Grade 6. F27. History of Science

Category	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
27. History of Science	123-131	8	5	2.11	56%	Marginal

The items in this category were of the matching type. They are reproduced below with the students' mean success rate for each item. The mean score for the category was 56%, which the Panel rated as Marginal. They expected a better knowledge of these scientists and inventors and especially of Garneau, the Canadian astronaut.

Match the people in LIST I with their discoveries, inventions, or achievements.
Put the letter of the correct word beside the person's name.

LIST I

124)	**77%**	**Alexander Graham Bell**	**A) telescope**
125)	**83%**	**the Wright brothers**	**B) telephone**
126)	**63%**	**Thomas Edison**	**C) airplane**
127)	**57%**	**Bombardier**	**D) light bulb**
			E) snowmobile

Match the people in LIST II with their discoveries, inventions or achievements.
Put the letter of the correct word beside the person's name.

LIST II

128)	**33%**	**Banting**	**A) gravity**
129)	**58%**	**Pasteur**	**B) insulin**
130)	**42%**	**Newton**	**C) pasteurization**
131)	**38%**	**Garneau**	**D) Canadian astronaut**
			E) radium

Summary of E. Attitude toward Science (cognitive items), F. Science and Society, and G. Nature of Science

These three areas contained 5 categories for the Grade 6 assessment. Generally they were not well done. The Interpretation Panel rated one category (Making Career Decisions) as Very Satisfactory, three as Marginal (Health, Nutrition and Agriculture, Environment, and History of Science), and one (Energy) as Unsatisfactory. Several of these marginal and unsatisfactory categories required some higher level thinking and generalizations from the students. They had great difficulty responding and expressing themselves. They did not know the important persons in the history of science as might be expected.

Summary of Grade 6 Written Test Results

The Grade 6 assessment consisted of 131 items in which the major areas of A. Content of Science, B. Processes of Science, D. Problem Solving and Decision Making, E. Attitude Toward Science, F. Science and Society, and G. Nature of Science were assessed. For the cognitive items the results were reported as raw scores and percents; for most of the affective domain the responses are reported for each item as the responses students selected.

For the cognitive domain, the students performed Satisfactory or better in eight out of the eighteen categories, Marginal in eight, and Unsatisfactory in three categories. The categories which the Panel interpreted as less than Satisfactory in the content area were: Terminology; Theories; Explanation of Physical Phenomena, Trends and Sequences. The categories judged Marginal in the process area are: Identifying, Collecting, Interpreting, Reporting Data, Building Models. Application of Knowledge was judged less than satisfactory in the Problem Solving and Decision Making area. Health, Nutrition and Agriculture, Energy, and Environment were judged less than satisfactory in the Science and Society area. History of Science was judged less than satisfactory in the Nature of Science area. The categories of Satisfactory or better performance were Facts and Concepts in the Content area; Observing, Measuring, and Making Inferences and Hypothesizing in the Processes of Science area; Cognition and Using Inquiry Techniques in the Problem Solving area; and Making Career Decisions in the Attitude toward Science area. To generalize it appears that the students are doing well in the categories which required the fairly conventional lower level thinking skills and emphases, but more poorly in application, synthesis and analysis and in areas of more recent emphases such as Science and Society and Nature of Science.

When the items were organized under the three content themes of the curriculum guide it can be stated that the students did best on the "Interdependency and Interaction am Organisms" theme and marginally poor on the other two themes.

For the affective domain it is difficult to generalize except to say that the children tended to favour science and science ideas but had difficulty in identifying the value of science in their lives in science related careers.

CHAPTER 5

GRADE 6 PERFORMANCE COMPONENT RESULTS

Performance testing was used to assess the level to which the students were attaining curriculum goals that are not possible to measure fully or are not adequately measured with the written test format. The Technical Advisory Committee determined the test categories which they believed should be measured using the performance component. The categories which were measured only by the performance component were: Category 12 -- Skills in Using Common Laboratory Equipment, Category 13 -- Skills associated with Safety, and Category 15 -- Following Instructions. Those categories which were measured by both written and performance components were: Category 5 -- Explanation of Physical Phenomena, Category 7 -- Observing and Classifying, Category 8 -- Measuring/Quantifying, Category 9 -- Identifying, Collecting, Interpreting, Reporting Data, Category 10 -- Making Inferences, Hypothesizing, Category 14 -- Cognition, and Category 16 -- Using Inquiry Techniques.

Two different and distinct formats were used for the performance testing: the Station Approach and the Individual Approach. The Station Approach format consisted of a circuit of six stations with one student working at each, for a prescribed time (5 minutes). Each student then moved to a different station for the next time interval. The procedure continued until all six students had completed the work at each of the stations. Each station contained a sheet of simple written instructions of procedures for the students to follow, and required the students to manipulate materials and apparatus, and make written responses on the sheet of paper, providing evidence of their performance. A testing supervisor was present to explain the stations, monitor the performance and collect the written responses.

The Individual Approach format tested one student at a time. The student was presented with a written task and a set of materials and apparatus. The testing supervisor clarified any concerns the student might have. The student then attempted the task. The testing supervisor carefully observed the student at work and completed a checklist which monitored the student's progress. The student also completed a work sheet. Two questions were asked of the students when they appeared to have finished. They were, "Is there anything else you would like to do in the investigation?" and, "Is there anything else you would like to say about the investigation?" There were four Individual tasks, with a child doing all four. The time needed for each task varied from 5 to 20 minutes, with each child being given time to finish the task.

The Station Test Performance Results

The Station Approach format was administered to 204 Grade 6 students from a sample of English language, French Immersion, and French language schools, during May and June of the 1986 school year. The six stations test for various aspects of six categories as follows:

Task (Station)	**Categories**
1. Circuits:	9. Identifying, Collecting, Interpreting, Recording, Data 12. Skills in Using Common Laboratory Equipment
2. Rocks and Minerals:	9. Identifying, Collecting, Interpreting, Recording Data 10. Making Inferences, Hypothesizing
3. Birds:	7. Observing/Classifying 9. Identifying, Collecting, Interpreting, Recording Data
4. Water:	5. Explanation of Physical Phenomena 8. Measuring/Quantifying 10. Making Inferences, Hypothesizing
5. Boats:	7. Observing/Classifying 9. Identifying, Collecting, Interpreting, Recording Data 10. Making Inferences, Hypothesizing
6. Divers:	5. Explanation of Physical Phenomena 7. Observing/Classifying 9. Identifying, Collecting, Interpreting, Recording Data

With this arrangement four categories in the Processes of Science area (7, 8, 9, 10) are assessed under more than one situation with different materials in different contexts. Two explanations of physical phenomena are requested (in Water and Divers), and students' skill in using laboratory equipment is assessed in Circuits. Table 26 below presents the detailed results of the Grade 6 students' performance for the six stations. The results from each station will be discussed separately and a summary of the results for the stations will be given.

TABLE 26

Results of Grade 6. Station Performance Approach

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
Circuits				**Students were asked to put together a circuit tested from the materials provided. They then tested articles to see if they were conductors.**
	1	12. Laboratory Skills	78%	Put together circuit
	2	9. Interpreting Data	65%	Penny - a conductor
	3	9. Interpreting Data	69%	Paper clip - a conductor
	4	9. Interpreting	67%	Nail - a conductor
	5	9. Interpreting Data	68%	Washer - a conductor
	6	9. Interpreting Data	75%	Rock - a non-conductor
	7	9. Interpreting Data	73%	Straw - a non-conductor
	8.	9. Interpreting Data	70%	Stick - a non-conductor
	9.	9. Interpreting Data	76%	Chalk - a non-conductor
Rocks and Minerals				**Students were asked to test the hardness of the minerals and then place them in order of hardness. Secondly they were asked to tell how they think the two rocks were formed.**
	11	9. Interpreting Data	39% 40%	Ordered minerals correctly from soft to hard Had one correct
	12	10.Inferring	23% 36%	Inferred how sandstone was formed Partly correct
	13	10.Inferring	14% 16%	Inferred how limestone was formed Partly correct
Birds				**Students were asked to observe 2 pictures of birds, note the differences, write what is different and how it is different.**
	21	7. Observing 9. Recording Data	36% 24% 11% 2% 22%	Stated a colour/pattern Stated size/shape Stated an aspect of environment Used an inference or content clue Stated another correct response
	22	9. Interpreting Data	88%	Gave correct reason (one or more)
	23	7. Observing 9. Recording Data	24% 29% 16% 2% 17%	Stated a colour/pattern Stated size/shape Stated an aspect of environment Used an inference or context clue Stated other correct response
	24	9. Interpreting Data	82%	Gave correct reason (one or more)

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
	25	7. Observing 9. Recording Data	18% 33% 12% 22% 2%	Stated a colour/pattern Stated size/shape Stated an aspect of environment Stated another correct response Stated an inference on context clue
	26	9. Interpreting Data	79%	Gave correct reason (one or more)
Water				**Students were asked to take the temperature of two glasses of water, and then mix them and take the resulting temperature. Then they were asked to predict a temperature from given figures.**
	31	8. Measuring	67% 9% 8%	Recorded temperature within two degrees Recorded temperature within five degrees Recorded temperature but did not use degree sign
	32	8. Measuring	50% 28% 7%	Recorded temperature within two degrees Recorded temperature within five degrees Recorded temperature but did not use degree sign
	33	8. Measuring	79% 3% 9%	Recorded temperature within two degrees Recorded temperature within five degrees Recorded temperature but did not use degree sign
	34	10. Predicting	10% 4% 36%	Predicted temperature within five degrees Predicted temperature within ten degrees Predicted temperature above either of the two temperatures
	35	5. Explaining	26%	Reasonable explanation
Boats				**Students were asked to float 3 boats in a pan of tap water and note how each boat floated. Then they were asked to float 2 of the boats in salt water and predict how the 3rd boat would float, and then give their reason.**
	41	7. Observing 9. Recording Data	77%	Gave the correct response for boat A
	42	7. Observing 9. Recording Data	70%	Gave the correct response for boat B
	43	7. Observing 9. Recording Data	74%	Gave the correct response for boat C
	44	10. Predicting	23% 20% 10%	Gave the most complete response Stated that Boat B would float Stated that Boat B would float higher in the salt water
	45	9. Interpreting Data	36%	Gave good reason

Divers				**Students were asked what happens and why when they squeeze bottle**
	51	7. Observing	15%	Gave complete response
		9. Recording Data	81%	Gave partial response
	52	7. Observing	32%	Gave complete response
		9. Recording	39%	Gave partial response
	53	5. Explaining	44%	Gave a good reason
	54	5. Explaining	24%	Explained why one diver behaved differently from the other

Station 1. Circuits This station required the students to put together a circuit from the materials supplied and then test articles to see if they were conductors.

The results as in Table 26 indicate that the majority of the students (78%) were able to put a circuit together.

They were relatively successful in determining whether the materials were conductors or not. The results varied from 65% to 78% correct.

Station 2. Rocks and Minerals. This station assessed students' skills in determining the relative hardness of three minerals. They were required to study two rock specimens and tell how they thought they were formed.

Few (39%) were able to order the minerals as to hardness, and 40% had one mineral correctly ordered.

Students had difficulty in telling how they thought the piece of sandstone was formed. A quarter were able to give a good explanation, with 36% giving a partially correct explanation. They found it even more difficult to tell how they thought the piece of fossiliferous limestone had been formed, with 14% giving a complete explanation and 16% giving a partially correct answer.

Station 3. Birds. For this station students were presented with two large coloured pictures of birds. They were asked to examine the pictures carefully to see what was different between the birds in them. For each difference they were to write down the difference and how it was different.

Most of the children were successful in this task. They were best at giving their first difference (95%), next best with their second difference (88%), and poorest for the third difference (87%). The correct reasons went down accordingly (88%, 82%, 79%).

It is noteworthy that a majority of students focussed on colour/pattern differences for their first difference, and size/shape differences for their second difference.

Station 4. Water. This station required the students to follow directions on the sheet for taking the temperature of the water in two glasses, and then mix them and again take the temperature of the water. Using these data, they were asked to predict the resultant temperature of two hypothetical glasses of water when they are mixed together, and explain the reason for their answer.

About two thirds of the students were able to take the temperature of the glasses of water within 2 degrees. About 10% more were able to do so within 5 degrees. After they mixed the water together 79% were able to take the temperature within 2 degrees.

Very few were able to interpolate the results and predict the resultant temperature for the hypothetical situation. Only 10% were within 5 degrees and a further 4% within 10 degrees. However, 26% were able to give some sort of reasonable explanation, such as it happened like that when they mixed the water in the two glasses, or the temperature should be between the two, or cold water cools the other water.

Station 5. Boats. For this station students were requested to float three boats in the aquarium containing tap water, and record what they saw about how the boats floated. The boats were the same size but made of woods of different densities. Then they were to float two of the boats in the aquarium containing the salt water, and observe how they floated. Using these data, they were asked to predict how the third boat would float.

Over seventy percent of the students were able to correctly observe and record the boats' relative positions. Very few were able to predict correctly how the third boat would float in salt water -- 23% gave a completely correct response, 20% said that the boat would float, and 10% stated that the boat would float higher in the salt water. Good reasons were given for their predictions by 36% of the students.

Station 6. Divers. This station tested the observation and explanation skills of the students. They had to observe the action of the cartesian divers when they squeezed the bottle.

The students' observation skills were good -- 15% stated that the black diver goes down to the bottom more quickly than the blue one (a complete response), and a further 81% said that the divers go to the bottom. When they were asked to note what happened to the water level in the droppers as they go up and down -- 32% stated the correct response, and 39% gave a partial response.

Less than 25% were able to give a correct explanation such as differing amounts of water/air in the droppers.

Summary of Station Approach Performance Results. Six different categories were assessed in different situations in this approach. These were four Processes of Science categories and a laboratory Skill category as well as an Explanation of Physical Phenomena category. It is possible to make some generalizations about the pupils' ability in certain categories across the tasks.

1. Students were very successful in making observations and recording them as noted in the tasks - Birds, Boats, and Divers. Results ranged from 70% to 95% correct.

2. They were able to measure using a thermometer with some facility -- two thirds within 2 degrees accuracy and a further 9% within 5 degrees.

3. For the tasks involving interpretation of data the context seemed to influence the results, ie., for the Circuit, 65% to 76% were correct, for the Birds, 79% to 88% were correct, whereas for the hardness test in the Rocks and Minerals, 39% were successful.

4. The students were least successful with questions which dealt with inferring and predicting. For the Rocks and Minerals station, only 14% and 23% were able to give correct inferences as to how they thought the rocks were formed. For the Boats station 23% were able to correctly predict the floating ability of the third boat.

5. Students' abilities to perform laboratory skills such as making a circuit were evidenced with a 78% success rate for this task.

6. Explanations of physical phenomena were not well done. For the Water station only 26% were able to make a reasonable explanation, and for the Divers only 24% did so.

The Individual Test Performance Results

The Individual Approach Format was administered to 134 Grade 6 students from a sample of English language, French Immersion, and French language schools, during May and June of the 1986 school year. The four tasks tested for laboratory skills by using actual apparatus for Category 12 -- Skills in Using Common Laboratory Equipment, and Category 13 -- Skills associated with Safety, as well as the category in the Content of Science area, Category 5 -- Explanation of Physical Phenomena. Other areas tested in this individual format were the Processes of Science, and the Problem Solving and Decision Making areas.

Table 27 below presents the results of the four Individual Tasks. Each set of results will be discussed separately and then a general summary will be made.

TABLE 27
Results of Grade 6. Individual Performance Assessment

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
Bouncing Balls				**Problem deals with finding out on which of 3 surfaces the ball bounces best.**
	61	16.Using Inquiry Techniques	16% 35% 41%	Controlled both variables and measured the bounce Had 2 of the above correct Had 1 of the above correct
	62	7.Observing	97%	Gave correct response for wood surface
	63	5.Explaining	86% 7%	Gave explanation that it is the hardest surface Gave other correct response
	64	9.Interpreting Data	74% 25%	Gave response that ball bounces worst on carpet Said ball bounces worst on foam
	65	14.Cognition	95%	Understood the problem
	66	8.Measuring	44% 32%	Dropped from measured height "Eyeballed" height
	67	12.Laboratory Skills	75%	Bounced ball carefully
	68	8.Measuring	39% 50%	Measured height of bounce "Eyeballed" height
	69	9.Recording Data	17% 80%	Recorded measured height Recorded answer
	70	16.Using Inquiry Techniques	59% 7%	Repeated trials on all 3 surfaces Repeated trials on less than 3 surfaces
	71	9.Interpreting Data	90%	Results consistent with data
	72		89%	Good explanation

Coloured Liquids				**Problem deals with taking the temperature of a liquid and adding drops of unknowns**
	74	9.Recording Observations	78%	Recorded colour change - blue
			7%	Stated colour changed
			5%	Stated no change
	75	9.Recording Observations	51%	Recorded colour change - green/yellow
			37%	Stated colour changed
			6%	Stated no change
	76	8.Measuring	89%	Measured water carefully
	77	12.Laboratory Skills	96%	Poured water carefully
	78	8.Measuring 12.Laboratory Skills	70%	Correct procedure & temperature within 2°C
			7%	Correct procedure only
			5%	Correct temperature only
	79	7.Observing	96%	Observed the changes
	80	10.Predicting	87%	Predicted using the data
	81	12.Laboratory Skills	99%	Handled equipment carefully
	82	13.Safety Skills	98%	Used safety precautions
	83	15.Following Instructions	70%	Followed in correct order
			22%	One step out of order
	84	9.Recording Data	98%	Recorded results
	85	16.Using Inquiry Techniques	12%	Repeated tasks after prompt
Sugar Lumps				**Problem deals with finding out if sugar lumps dissolve as quickly as ordinary loose sugar**
	91	10.Predicting	88%	Predicted loose sugar
			11%	Predicted sugar lumps
	92	5.Explaining	5%	Loose and smaller pieces
			46%	Loose only
			28%	Smaller pieces
	93	9.Recording Observations	55%	Recorded observations correctly
	94	9.Recording Observations	74%	Observed correctly
			22%	Stated no difference if water stirred
	95	9.Measuring	18%	Correct-controlled time
			30%	Guessed at time
			26%	No control, e.g. stirred both
	96	9.Recording Observations	94%	Recorded observation
	97	15.Following Instructions	73%	Followed instructions
			6%	Needed prompting
	98	8.Measuring	40%	Used equal amounts of water and of sugar
			42%	Used equal amounts of water, not sugar
			2%	Used equal amounts of sugar, not water
	99	9.Interpreting Data	75%	Results consistent with data

	100	12.Laboratory Skills	98%	Handled equipment carefully
	101	13.Safety	98%	Used safety precautions
	102	14.Cognition	79%	Understood the problem
	103	16.Using Inquiry Skills	55% 13%	Repeated same as first time, stirring Repeated and now used correct procedures
	104	8.Measuring	34% 5%	Used balance correctly Used balance incorrectly
Meal Worms				**Problem deals with finding out if the meal worms prefer to eat one of these foods more than others**
	106	12.Laboratory Skills	60% 2%	Carefully handled meal worms Handled meal worms carelessly/roughly
	107	12.Laboratory Skills	80%	Used forceps to handle meal worms
	108	16.Using Inquiry Skills	74%	Used 2 or more worms
	109	8.Measuring	69%	Measured equal amounts of food
	110	9.Measuring	68%	Placed worms at same distances away from food
	111	9.Measuring	3% 19%	Timed eating carefully, using a clock Timed approximately
	112	7.Observing	48%	Observed, using the hand lens correctly
	113	9.Interpreting Data	78% 4%	Inferred correctly from data Used incomplete data
	114	9.Recording Data	84%	Recorded data accurately
	115	12.Laboratory Skills	97%	Handled equipment carefully
	116	14.Cognition	90%	Understood the problem

Individual Task 1. Bouncing Balls This task asked the students to find out on which surface the ball bounced best. They were asked to describe their method, tell on which surface the ball bounced best and why, and then state on which surface the ball bounced worst. They were supplied with three different surfaces, a ball, and a yardstick. The students had to decide how to carry out the investigation and report their results without any assistance from the tester. Most children tackled the task eagerly. The results were:

1. Nearly all the children (97%) made accurate observations.

2. Few children (44%) dropped the ball from a measured height; 32% "eye-balled" the height. The remainder didn't bother to do either.

3. Few children (39%) measured the height of the bounce; 50% "eye-balled" the height of bounce. The remainder did neither.

4. Nearly all had results consistent with their data for the best bouncing surface. However, they were divided as to which surface the ball bounced worst on -- 74% said the carpet, and 25% stated the foam.

5. Three quarters of the students bounced the ball carefully.

6. Nearly all the children seemed to clearly understand the problem.

7. With respect to using inquiry techniques, only 16% controlled both variables and measured the height of the bounce; 35% had two of the above correct. Nearly two thirds repeated their trials on all three surfaces, and 7% repeated trials on less than 3 surfaces.

Individual Task 2. Coloured Liquids. For this task the students had to follow directions in taking the temperature of water, and adding various drops of liquid to the beaker. Students were required to make careful observations and to follow instructions carefully. A summary of the children's abilities as measured by this task is:

1. Observing skills were very satisfactory and almost all children recorded their observations.

2. Most measured the water correctly, but fewer (70%) were able to take the temperature correctly.

3. Most (87%) were able to predict using the data they had gathered.

4. Nearly all poured the water carefully, and handled the equipment carefully.

5. Most (70%) followed the instructions through all the steps. Twenty-two percent had one step out of order.

6. With respect to the use of inquiry techniques only 12% repeated their trials even after a prompt.

Individual Task 3. Sugar Lumps. For this task the students were given the problem "Find out if the sugar lumps dissolve as quickly as the ordinary loose sugar". They were asked to predict, explain their prediction, and then carry out the investigation. Then they were asked to repeat the investigation. The following results were obtained:

1. Most of the children were able to make predictions, but few were able to give good reasons for their predictions. Only 5% gave a complete response, whereas 74% gave partially correct answers.

2. Measurement was an important part of this task but only 40% used equal amounts of water and of sugar; forty-two percent used equal amounts of water, not sugar; and 2% used equal amounts of sugar, but not water. Only 18% controlled the time of stirring for both types of sugar; thirty percent guessed at the time. The remainder did not seem to consider this factor.

3. Most of the children recorded their observations correctly as in some cases the water did not change colour.

4. For 75% of the children their results were consistent with their data.

5. Nearly all the students handled the equipment correctly and safely.

6. Most of the students (79%) seemed to understand the problem, and 55% repeated their trials as per the instructions on the sheet.

Individual Task 4. Meal Worms. This task was very open-ended. The students were given the problem of finding out if meal worms preferred to eat one of the given foods more than others. They had to record their procedures and come to a conclusion. The results were:

1. All of the students appeared interested in this task, with 48% using the magnifying glass to observe the meal worms.

2. Most of the students seemed to understand the problem. Measurement was a critical factor -- 69% measured equal amounts of food, 68% placed the worms at equal distances from the food, but only 3% timed the eating accurately (19% did an approximation).

3. Most (84%) recorded their data accurately, and 78% inferred correctly from their data.

4. Most of the children (80%) picked up the mealworms with forceps. Slightly more than half handled the worms carefully. The equipment was used carefully by 97% of the students.

5. Over three quarters of the students were able to set up the experimental procedure. Evidence of this was given by using more than two worms and, as noted above, placing the worms at equal distances from the food, and measuring equal amounts of food.

Summary of Grade 6 Performance Component

The Grade 6 Performance component consisted of six Station Format tasks and four Individual Format tasks. The performance component was specifically used to assess certain categories within the assessment framework which are difficult if not impossible to assess by written tests, and to supplement the information gained from the written test for several other categories.

Three categories were assessed only by the performance test. The category related to using laboratory equipment was assessed mainly by the

Individual Approach Format where the testing supervisor watched the children at work and recorded their activities. Three quarters of the children bounced the ball carefully, whereas nearly all the children handled the laboratory equipment carefully and safely. Over three quarters were able to assemble the circuit correctly. About three quarters of the students followed the instructions carefully when they were written out in detail. In some cases they were free to design their own procedures.

Seven categories were assessed by both Written and Performance components. For the four tasks in which explanations were asked, the students' success varied greatly with the difficulty of the situation.

Categories which involved the processes of science were extensively tested using both formats. The students were very good at making and recording observations. Many aspects of measurement were assessed with results varying as follows:

- About one third used a balance to determine the mass of (weight) the sugar.
- About two thirds were able to determine the temperature of a liquid.
- Nearly all were able to pour liquid into a beaker and determine the volume.
- In the Bouncing Ball investigation
  - about one-half dropped the ball from the same height each time.
  - less than one-half measured the height of the bounce.
- In the Sugar Lumps investigation
  - less than one-half used equal amounts of water and sugar.
  - almost none used equal time intervals.
- In the Meal Worms investigation
  - about two-thirds used equal amounts of food.
  - about two-thirds placed the worms at equal distances from the food.
  - almost none used equal time intervals for feeding.

Their ability to interpret data varied according to the context of the task. Inferences and predictions were poorly done in the Station tasks and better done for the Individual tasks where the situations were probably more familiar (Water, Sugar Lumps), suggesting that the context may be an important element to consider when measuring achievement.

The children tackled all the tasks enthusiastically and nearly all seemed to understand the problems presented.

The area where most weaknesses were evidenced was that of using inquiry techniques. About one-sixth were able to control variables in the Bouncing Ball task, but three fifths repeated their trials. For the Coloured Liquids only 12% repeated the task even after verbal prompting. For Sugar Lumps, almost two thirds repeated the task as instructed on the sheet. For the Meal Worms most did several trials using more than one worm, and as noted above, a good proportion controlled for both amount of food and distance.

Recommendations Based on the Grade 6 Written Component

The assessment results indicate that the students performed satisfactorily on less than half of the categories tested. Many of the satisfactory categories tended to be those associated with "traditional" science, such as the learning of facts and concepts in the Content of Science heading, and observation and measurement in the Processes of Science heading.

Recommendation: More emphasis should be placed on the use and understanding of the terminology of science and on the higher levels of thinking, i.e. theories, explanations of physical phenomena, and trends and sequences.

Recommendation: Teachers should continue the satisfactory work in most areas of teaching of the science processes, but place more emphasis on drawing and labelling graphs, looking for patterns in data, hypothesizing and the development of models to help explain physical phenomena. Students require more open-ended activities where they make some decision e.g. determining the scale for a simple graph.

Under the Problem Solving and Decision Making heading the mean score was less than 50%. Many students could not identify problems nor use scientific knowledge to solve problems.

Recommendation: Emphasis should continue to be placed on all aspects under the Problem Solving and Decision Making heading, particularly in helping students to apply scientific knowledge to problems on real situations using real objects. Open-ended problems for which students have to design "fair tests" should be given.

The students' knowledge of science and society topics was less than satisfactory for all the aspects tested. Students at the Grade 6 level should be familiar with current issues relating to the science topics studied.

Recommendations: All Units at the upper elementary level should include Science and Society discussions where relevant. As well, students' knowledge of leading figures in science and technology was lacking and it is recommended that this aspect be incorporated into the science program.

For the affective domain it is noted that students preferred doing science rather than viewing or reading about science. Their attitudes towards science and scientists were fairly positive but it is noted that the above recommendation to teach more Science and Society aspects should provide them with more knowledge from which to base their attitudes and opinions in this area.

Recommendation: That each teacher of Grade 6 science stress those elements which will motivate their students to read and to research topics in science.

The students had more difficulty with items having written responses and explanations. They generally responded when asked for just one answer to items, but when asked for a second or third response many were unable to attempt this.

Recommendation: More emphasis should be given to having students describe, record, and explain observations orally and by written methods. Records of science investigations, in the students' own words, should be stressed.

The students performed poorly, by comparison, on items from the Physical Science and Earth Science content themes: Changes in Matter and Energy, and Earth/Space/Time. The success rate on the Life Science theme: Interdependency and Interaction among Organisms, was judged Satisfactory.

Recommendation: Teachers should be encouraged to give equal emphasis to all of the curriculum themes. In-service sessions should be made available for teachers who do not feel confident with various content themes.

CHAPTER 6

GRADE 9 WRITTEN TEST RESULTS

Chapter 6 reports the Grade 9 results in accordance with each of the seven major headings. The tables present the categories comprising each major heading including the item numbers, the total number of items, the mean raw score, the standard deviation, the mean percent correct, and the rating given by the Interpretation Panel for the category. Each category is then summarized and sample items are presented.

A. Content of Science

The assessment of the students' acquisition of science content at the Grade 9 level is accomplished through a hierarchy of cognitive structures beginning with knowledge of facts and terminology, proceeding through concepts/relationships, theories and conceptual schemes to explanation of physical phenomena, and trends and sequences, the latter requiring analysis and synthesis. This major heading is comprised of 42 test items grouped into 6 category subtests (A1 - A6) summarized below in Table 28.

Table 28

Results of Grade 9. A. Content of Science (9A)

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
1. Facts	1-14	14	5.67	2.20	40%	Marginal
2. Terminology	15-18 101-107	11	3.74	1.75	34%	Unsatisfactory
3. Concepts	19 108-115	9	4.75	2.04	53%	Satisfactory
4. Theories	116-119	4	0.54	0.84	13%	Unsatisfactory
5. Explanation	20 120	2	0.55	0.62	27%	Unsatisfactory
6. Trends	121-123	2*	0.52	0.74	26%	Unsatisfactory
Total Content Area		**42**	**15.76**	**5.63**	**37.5%**	**

* Item #121 was a selection item not a test item

** No summary interpretation by Panel

Category A1. Facts. For the purpose of the Grade 9 Science Assessment "facts" were defined in accordance with Bloom's cognitive level of knowledge, including the definition of terms e.g. item number 11 requires the students to identify the definition of a chemical element. The students were able to answer 40% of the 14 items comprising this subtest. The Interpretation Panel rated this score as Marginal and commented that question #14 asking for the name of Manitoba's new official bird was "a poor question choice".

Students did reasonably well on items dealing with the microscope, environmental competition, the cell, the North Star, and mechanical advantage. They did poorly on items dealing with genetics, crystals, erosion, Earth's moon, chemical elements, pH, solutions, and the shape of a planet's orbit.

With respect to the six subject areas comprising the Grade 7-9 curriculum the students seemed to know facts best in Environmental Science followed by Life Science, Space Science, Physics, Chemistry and lastly Earth Science.

Category A2. Terminology. Terminology may be defined as comprehension with respect to Bloom's cognitive taxonomy. The assessment questions in this subtest generally asked for some elaboration of fact. This particular subtest consisted of four multiple choice questions and seven short answer questions. The mean score for the multiple choice items was 48%. For the short answer questions the mean score correct was 26%. The total mean percent correct for the terminology subtest was 34% or 8% less than the total cognitive testing mean. The Interpretation Panel rated these results as Unsatisfactory and commented that question #16 was "difficult to interpret" and that #17 was "a difficult question to read". They also felt that question #103 was "poorly worded".

For the terminology subtest the students did reasonably well on items dealing with comets, sunspots, reflection of light, the barometer and cold fronts. They did poorly on items dealing with atomic number, environmental niche, naming forms of bacteria, the law of dominance, the circulatory system, and isobars.

Relative to the six subject areas comprising the Grade 7-9 curriculum the students performed best in terminology for Space Science followed by Environmental Science, Physics, Earth Science, Chemistry and lastly Life Science.

Category A3. Concepts/Relationships. Concepts suggest the nucleus about which knowledge is organized. For example, the concept of erosion relates to movement of Earth's particles by forces such as wind, gravity, moving water, earthquakes, etc. Concept relationships may be thought of as being above Bloom's cognitive level of comprehension. Grade 9 students received their highest mean percent correct, in the major heading of "Content", for the Concepts subtest (53%). This score was 11% higher than the mean percent correct for the overall cognitive area. The Interpretation Panel rated this score as satisfactory and commented that the diagram for questions #113-114 was "poor".

The Concepts/Relationships subtest consisted of one multiple choice item and eight short answer questions. The students did well on items dealing with identifying producers and consumers, fertilization, gestation period, single pulleys and revolution vs. rotation. They did poorly on items dealing with erosion.

In terms of the subjects comprising the Grade 7-9 curriculum the students achieved best for concepts in Environmental Science followed by Physics, Space Science, Life Science, and lastly Earth Science.

Category A4. Theories and Conceptual Schemes. Theories in science, for grade nine students, may be thought of as: "research supported explanations of physical or natural phenomena". Any grade nine student can have a theory but to be acceptable it should have more support than a simple hypothesis. A conceptual scheme is an ordering of concepts according to a particular logic. This logic may offer an explanation of a natural or physical phenomena. For example, the logic of flight may be explained by ordering the concepts of drag, lift, thrust, and gravity into a particular conceptual scheme. Discussing theories and relating concepts according to a particular logic requires cognitive operations that exceed Bloom's level of knowledge and comprehension. The Interpretation Panel rated the achievement for this category as unsatisfactory.

The subtest "Theories and Conceptual Schemes" consisted of four short answer questions. The questions asked for at least a rudimentary understanding of two well recognized theories: the "Big Bang Theory" and the "Kinetic Molecular Theory". Students were expected to give two statements about each theory that would indicate their understanding of the theory. The results of this subtest were extremely low. For the Big Bang Theory only 21% of the students were able to make one acceptable statement. For the Kinetic Molecular Theory 14% were able to make a single acceptable statement. Eleven percent or less of the students were able to make a second acceptable statement for either theory. For the Kinetic Molecular Theory 37% of the students did not write a response of any sort. Students seem familiar with such terms as molecular motion and gas pressure but they do not seem able to relate this knowledge to the major supporting theory.

With respect to the six subject areas comprising the grade 7-9 curriculum, the students scored low for theories and conceptual schemes in Physics and Chemistry.

Category A5. Explanation of Physical Phenomena. This category is broader than formulating a theory or a conceptual scheme. While it may embody either or both of these ideas it also opens the door to forms of analysis, synthesis and evaluation. An explanation such as the reason for the difference in mass between the wood put into a stove and the ashes removed from the ash bin could involve relationships, etc.. This subtest consisted of only two questions, one multiple choice and one requiring a written explanation. The students received a mean score of 28% which was considerably below the 42% mean score received by the same students for the total cognitive area. The Interpretation panel rated the results of this category as Unsatisfactory with no specific comments.

The students did best on the multiple choice item dealing with the refraction of light (42% gave a correct response). The question requiring a written response was answered correctly by only 13% of the students.

120) A 5 kg log was burned in the stove and 0.5 kg of ashes were taken from the ash bin. What happened to the other 4.5 kg of mass?

While 19% of the students responded with a partially correct answer, 14% of the testing sample did not respond to this item.

Relative to the six subject areas comprising the grade 7-9 curriculum the students achieved reasonably well on the Physics-related items and less well on the Chemistry related items.

Category A6. Trends and Sequences. This category subtest identifies the student's knowledge of science as it relates to common trends occurring in today's technological society. The students were asked to select one trend from five options and then explain two scientific or technological developments that affect the elected trend.

121

Select one of the following trends and then list two developments in Science and/or Technology that make the trend possible.

(a) the increasing number of allergic reactions among children in North America
(b) greater use of organ transplants
(c) more accurate weather prediction
(d) the greatly expanding knowledge of space
(e) the use of new energy sources and conservation of energy

121) I selected the trend listed as letter _____.
122) One development that affects this trend is:
123) A second development that affects this trend is:

Twenty-nine percent of the students opted for "d - The greatly expanding knowledge of space". Twenty-three percent of the testing sample students opted for "b - Greater use of organ transplants". Sixteen percent opted for "c - More accurate weather prediction". Twelve percent opted for "a - The increasing number of allergic reactions among children in North America", and ten percent opted for "e - The use of new energy sources and conservation of energy". Eleven percent of the testing sample students did not elect any of the options. The Interpretation Panel rated the results of this subtest as Unsatisfactory and commented: "too much reading, wording difficult".

After selecting a trend thirty-one percent of the testing sample students were able to state one acceptable development relating to their elected trend. Twenty-one percent of the students were able to state a second development relating to their elected trend.

In light of the fact that each student could elect the trend for which developments were to be stated, the testing sample did rather poorly on this category subtest.

While this category subtest does not relate directly to any particular subject area, it does measure the extent to which the students are knowledgeable of current scientific and technological developments.

Summary for Content of Science

Content of Science composed a "Major Heading" of the Grade 9 assessment instrument. It sampled the science curriculum content which students are expected to achieve by May of their grade nine year. Although some science classes may have opted to leave particular sections such as "simple machines" until the last few weeks of the school year this is not expected to affect the overall pattern of results.

The Content of Science portion of the cognitive section was the longest of the major headings [42 items - 6 category subtests]. While the 1181 student sample received a "satisfactory" score interpretation in the subtest Concepts of Science, there were no "very satisfactory" and no "strength" score interpretations for any of the six subtests. Five of the six category subtests composing Content of Science received a "marginal" or "unsatisfactory" score interpretation.

Content of Science received a total mean percent right score of 38%. This was the lowest mean score for any major heading of the cognitive domain area. The highest score received by any individual student for this 42 item major heading was 38/42 and the lowest score received by any individual student was 0. The median score was 15. There was a reasonably normal distribution of marks.

The relatively low overall percent correct score for Content of Science needs further investigation in order to seek answers to such questions as:

1. **Why are facts such as the pH of a neutral solution (test item #12, 21.8% correct) which is an item taken directly from the approved curriculum (grade eight chemistry - objective #10), not being retained by students? [This particular test item is of special concern because acids and bases are also included in the grade 5 curriculum (objective 9 page 175)]**

2. **Why did a significant number of students (152) receive an overall score of 22% or less correct? Are these students really trying to receive the best possible score or is our system such that many students are not willing to "work" for an anonymous result?**

3. **Is our present curriculum suitable for both students and teachers?**
4. **To what degree are Manitoba students being motivated to learn science?**
5. **Do school programs allot enough time for science?**

B. Process of Science

The individual processes of observation, measurement, collecting and organizing data, hypothesizing, making inferences, and the building-testing of theoretical models are taught and practiced as an integrated whole beginning with simple processes at the lower grades and progressing to the integrated process level by Grade 9. The assessment of each Grade 9 student's acquisition of the processes of science was accomplished at the level of integration/experimentation. There were 25 questions under this major heading. All of the questions were grouped under a single category (B7-11) subtest called Processes of Science. The results are summarized below.

Table 29

Results of Grade 9. B. Processes of Science

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel Rating
1. Integrated	124-141	*25	10.2	4.2	42%	Satisfactory to Marginal

* one item was not used as part of the statistical findings

Categories B7-11, Processes of Science. This category subtest was comprised of 7 multiple-choice questions, 5 matching questions and 13 questions calling for a written response. Students received a 57% average on the seven multiple-choice items (#21-27) which was greater than the "adequate" level set by the Interpretation panel. It is interesting to note that 71% of the students were able to select the leaf branch that had the greatest transpiration rate for question #21.

21)
Which branch in this experiment would you expect to have the greatest transpiration rate?

10% A) branch #1
***71% B) branch #2**
11% C) branch #3
6% D) branch #4

Students received a 72% average on the 5 matching questions. This was at the desirable level set by the Interpretation Panel. These questions (#135-139) asked the students to match a scientific phenomena with an illustration of the most appropriate model. The students received a 21% average on the 13 process questions asking for written responses. While the Interpretation Panel did not consider these questions separately this is surely an unsatisfactory rating.

The students did best on the process questions dealing with reading and interpreting data tables, making inferences, reading graphs and selecting appropriate models. These same students did poorest on questions asking for observations, questions asking for an hypothesis, questions asking for identification of dependent and independent variables and questions calling for recognition of variables in need of control for particular experiments.

Summary for Processes of Science

The questions pertaining to the Processes of Science were based upon several subject areas of science. A deliberate attempt was made to keep the content requirement simple and to stress that the scientific process is being tested. The results of this major heading indicate that grade nine students do well in the processes that are concerned with data tables and illustrations but they do poorly on the basic experimentation processes of observing, hypothesizing, identifying the cause and effect variables and in controlling variables.

C. Skills for Science

This major heading consisted of two category subtests, C12 (Skills Using Laboratory Equipment) and C13 (Skills Associated with Safety). While it is acknowledged that the performance component of the assessment will certainly assess some skills, the Grade 9 TAC decided that there was a content element of safety that should be included in the written portion of the assessment. Category C12 embodied 14 questions, 3 multiple choice, 8 fill-in-the-blank, and 3 calling for a written response. Category C13 consisted of 7 multiple choice items, and the results are summarized in Table 30.

Table 30

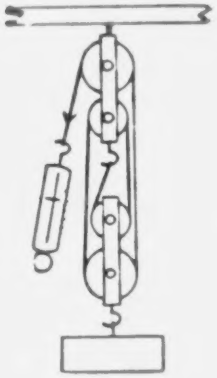
Results of Grade 9. C. Skills for Science (9C)

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Mean Percent	Panel Rating
C12. **Skills Using Lab Equipment**	28-30 142-152	14	5.75	2.73	41%	Marginal
C13. **Skills**	31-37	7	4.07	1.56	58%	Satisfactory
Total Content Area		**21**	**9.82**	**3.60**	**47%**	*****

*No summary interpretation by Panel

Category C12. Skills Using Laboratory Equipment. This category subtest assessed the student's ability to use common laboratory equipment. The mean correct score for this category was 41%. Students were generally able to read the protractor well. They knew how to clean the lens of a microscope but had little knowledge of how to focus it. Preparing a wet-mount slide was no problem for 45% of the students but only 7% were able to describe how to read the graduated cylinder using the terms meniscus, liquid and eye level. Nearly half the students knew why a thermometer is kept away from the bottom of a beaker of heated liquid and 41% knew where the hottest part of burner flame was. Only 17% of the students were able to determine the theoretical mechanical advantage of a pulley system by counting the number of strands holding the moveable block.

152) What is the theoretical or ideal mechanical advantage of the following pulley system?



The Interpretation Panel rated the student results on this category as Marginal and commented that the pulley item (#152) was "poorly worded" and that "students use the protractor very little in grades 7-9".

Category C13. Skills Associated with Safety. This category subtest assessed the students familiarity with safety procedures that are common to the grade 7-9 science laboratory. The subtest was comprised of seven multiple choice items. With respect to safety procedures to be acknowledged when heating liquids, 65% of the students knew that a flame should not be put directly under a non-pyrex container and that the container should not be sealed when heating a liquid. Protective glasses were acknowledged as necessary when doing a laboratory experiment by 57% of the students. Only 14% of the students seemed to be knowledgeable of the dangers associated with the culturing of a pathogenic substance.

32) Why is it very important, from a safety point of view, to keep the lid on the petri dish when culturing inoculated agar?

***14% A) the culture may contain a dangerous microbe**
11% B) to keep other bacteria from the culture
5% C) to prevent damage to the culture
6% D) to prevent dust from entering the culture
59% E) all of the above

Many of the students (78%) were aware that they should report all injuries to their teacher immediately and 85% of the students were familiar with the dangers associated with looking directly at the sun through a telescope. The Interpretation Panel rated this category as Satisfactory and commented that the answer to question #35 should be "never".

35) When should you taste substances in the science laboratory?

3% A) only when you are sure it will not hurt you
60% B) never
2% C) only when the substance is not an acid or base
***30% D) only when the teacher says that it is not dangerous**

Summary For Skills in Science

The marginal rating received by grade nine students for laboratory skills may be related to the low percentage of correct responses for the processes associated with the science experiment. Safety in the science laboratory is a crucial area and the Satisfactory rating given by the Interpretation Panel may be misleading. Can we afford to have 22% of our students not telling their teacher when they receive an injury in the science laboratory or 15% of the students not knowing that the eye can be damaged by looking at the sun through a telescope?

D. Problem Solving and Decision Making

This major heading includes four distinct categories: D14. Cognition, D15. Following Instructions/Using algorithms, D16. Using Inquiry Techniques, D17. Application of Knowledge. Collectively these four categories embody an assessment of the student's ability to transfer important problem solving and decision making attributes from the science classroom to more realistic life situations. Many educators believe that this major heading represents a key goal of not only science education, but education in general. Results are summarized below.

Table 31

Results of Grade 9. D. Problem Solving and Decision Making Results

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Mean Percent	Panel Rating
D14. Cognition	153-156	4	2.40	1.23	60%	Strength
D15. Following Instructions	38-42	5	1.79	1.11	36%	Satisfactory
D16. Using Inquiry Techniques	157-160	4	1.92	1.18	48%	Satisfactory
D17.	161-162	2	0.77	0.80	38%	Satisfactory
Totals		**15**	**6.87**	**3.06**	**46%**	*

* No summary interpretation made by Panel

Category D14. Cognition. This category may be described as; "The perception of a problem as a problem". For example, being able to recognize a discrepancy in any graph curve that does not extrapolate as the data might predict. Cognition with respect to problem solving would also include the ability to select relevant information for obtaining a particular solution. Discrepancies between expected and actual events involve problem cognition, e.g. Why does a heated object not pass through an opening it could pass through when cold?

This subtest was comprised of four questions, each requiring a written response. Question #153 required the student to interpolate from a data table and question #154 required the student to extrapolate from the same data table. Over 70% of the students were able to answer these questions correctly. Only 36% of the students were able to explain that sound does not travel through a vacuum. (Question #155 from an extension unit on sound in the grade 8 curriculum.) Question #156 dealt with the oxidation of a copper penny. This chemistry related question was answered correctly by 62% of the students.

The Interpretation Panel rated the results of this category subtest as Strength with no specific comments.

Category D15. Following Instructions Using Algorithms. A problem continues to be a problem until a solution is found. The ability to follow instructions in either the cognitive or the psychomotor domain is an essential element in problem solving. An algorithm may be thought of as a way of solving a problem, or as a special set of instructions, e.g. for a plane mirror; [angle of reflection = angle of incidence]. Five multiple choice questions formulated this category subtest. Students received a 36% mean correct score.

Question #38 required knowledge of an algorithm (for the area of a rectangle) and simple computational skills. These requirements were satisfied by 54% of the grade nine students. Question #39 required knowledge of the alogrithm for work-in, work-out with respect to a first class lever. Only 32% of the students were able to respond correctly to this item. Question #40 involved an algorithm for dominant and recessive genes. This question was answered correctly by 45% of the students. Only 10% of the students were able to answer question #41 correctly.

41) What is the mechanical advantage (M.A.) of a simple machine that will lift 10 kg of mass with 9.8 Newtons of force?

6% A) 100
*10% B) 10
46% C) 98
14% D) 980
22% E) 0.98

This question required knowledge of the algorithm for mechanical advantage of a simple machine as well as the gravitational force constant. Question #42 required knowledge of the algorithm for work in S.I. This question was answered correctly by 38% of the students.

The Interpretation Panel rated the results of this category subtest as Satisfactory and commented that question #41 was "poor". Every question in this subtest required the student to perform mathematical calculations of some sort; in this light the 36% mean score may be indicative of ability in this area and knowledge of machines as well as knowledge of specific algorithms.

Category D16. Using Inquiry Techniques. This category subtest involved the use of the experimental procedure in science. This technique requires the students to perceive a problem and its solution in accordance with their own knowledge of concepts and procedures.

The subtest was comprised of 4 questions, each requiring a written response. The mean percent correct was 48. Questions #157, 158 and 159 dealt with an environmental issue involving an increase in cougar population along the Red River. Students received scores of 56%, 31%, and 75% respectively for the items. Question #160 was a more open-ended question asking for a complete experimental procedure to determine food preference for mice. Students received a mean score of 31% for this item.

158) What might be the result of the increase in cougar population on the animal community along the Red River?

The Interpretation Panel rated the student response for this category as satisfactory with no particular comments.

Category D17. Application of Knowledge. In this category students use their knowledge of science and the scientific method to solve problems that are related to situations that occur outside the classroom. The category consists of two questions each requiring a written response. The mean percent correct for this subtest was 38.

Question #161 asked the students to explain how a fisherman might use his/her knowledge of the feeding and breeding habits of the jackfish. This item was responded to correctly by 43% of the students. The remaining question (#162) asked how a chemist might use his/her knowledge of the Periodic Table to assist a manufacturer of cooking pots. This question was answered correctly by 34% of the students.

The Interpretation Panel rated the student response for this category as Satisfactory and commented that question #162 was poorly constructed.

Summary of Major Heading D. Problem Solving and Decision Making.

While students did relatively well in Cognition and Using Inquiry Techniques, they were lower in the category requiring mathematical calculation and in the category requiring application of knowledge. An item by item analysis indicates that students are doing satisfactory or better in reading data tables, extrapolation and interpolation of data, recognizing oxidation, calculating area, determining genotype, analyzing an environmental problem, proposing solutions to an environmental problem, and applying knowledge of jackfish. Students are doing less than satisfactory in knowledge of sound transmission, first class levers, mechanical advantage, gravitational force constant, S.I. units generally, determination of work in and out for simple machines, practical experimental procedure and the Periodic Table.

E. Attitude Toward Science

This major heading constitutes a portion of the non-cognitive or affective assessment results. It comprises approximately 7% of the total assessment. The category subtests within this major heading focus upon the students' enjoyment of science (E18), valuing science as an important aspect of their lives (E19), adopting attitudes of science (E20) and expressing an awareness of the career opportunities in science (E21). The results are reported in Table 32.

Table 32

Results of Grade 9. E. Attitude Toward Science (9E)

Categories	Question No.	Responses ** A	B	C	D	E	No Response %
E18.	43	9.1%	14.4%	33.2%*	32.2%	9.6%	1.6%
Enjoying	44	4.2%	9.4%	27.6%	28.1%	28.9%*	1.8%
Science	45	22.7%	12.4%	33.5%*	2.8%	26.2%	2.4%
#43-45							
E19.	46	79.3%	6.9%	10.5%	-	-	1.8%
Valuing	47	16.2%	57.7%*	24.0%	-	-	1.7%
Science	48	51.9%*	35.9%	9.6%	-	-	1.8%
#46-49	49	12.3%	59.0%	26.2%	-	-	1.6%
E20.	50	3.6%	4.4%	51.4%*	38.4%	-	1.9
Adopting	51	37.8%	14.6%	42.6%*	-	-	1.9%
Attitudes	52	22.4%	47.2%*	6.9%	15.7%	-	1.9%
of Science	53	45.0%	12.4%	40.0%	-	-	1.9%
#50-58	54	66.8%*	12.7%	18.1%	-	-	1.9%
	55	21.9%	52.2%*	23.5%	-	-	1.9%
	56	14.0%	68.2%*	15.6%	-	-	1.9%
	57	23.7%	50.0%*	22.8%	-	-	2.1%
	58	83.7%*	4.4%	9.0%	-	-	2.3%
E21.	59	9.5%	18.6%	67.4%*	-	-	4.1%
Making	60	51.6%*	34.3%	9.4%	-	-	4.3%
Career	61	5.2%	16.7%	73.7%*	-	-	3.9%
Decisions	62	9.2%	35.6%	50.7%*	-	-	4.0%
#59-74	63	45.4%*	38.3%	11.9%	-	-	4.1%
	64	4.1%	6.9%	84.4%*	-	-	3.8%
	65	5.6%	12.7%	77.1%*	-	-	4.1%
	66	13.0%	42.2%*	40.2%	-	-	3.8%
	67	6.4%	15.5%	73.8%*	-	-	4.0%
	68	33.0%	51.9%	11.0%	-	-	3.8%
	69	60.0%*	29.4%	6.3%	-	-	3.9%
	70	56.0%*	28.1%	11.9%	-	-	3.9%
	71	27.9%	54.4%*	13.8%	-	-	3.6%
	72	55.0%*	26.8%	14.4%	-	-	3.7%
	73	30.4%	44.6%*	20.8%	-	-	4.0%
	74	30.1%	48.4%*	17.4%	-	-	3.6%

* The largest percent of choice for the item

** Because options varied from question to question for the attitudinal questions, the reader must refer to a copy of the grade 9 test.

Category E18. Enjoying Science. This category subtest was comprised of three multiple choice questions. Question #43 asked the student directly: "How much do you enjoy your science classes?" While 42% of the students said "quite a bit" or "very much", 25% said "not at all" or "very little". Question #44 attempted to assess if students enjoyed science related activities outside the classroom. The results indicate that 57% of our Manitoba grade 9 students seldom or never pursue a science related activity outside the classroom. Question #45 was designed to assess the subject area of science most enjoyed by students. The subject area enjoyed most was the life sciences i.e. working with plants and animals (34%). Space Science i.e. working with telescopes and learning about space, was most enjoyable to 26% of the students. Nearly 23% of the students said they enjoyed Chemistry related activities the most. Physics related activities were enjoyed most by 12% of the students and only 3% of the students indicated that they most enjoyed Earth Science related activities i.e. working with rocks and minerals.

While not surprising, the results of this category subtest reinforce the notion that many students (25%) do not enjoy the science classroom. The results also indicate that the areas of Physics and Earth Science should be promoted to a greater extent by science educators.

Category E19. Valuing Science. The purpose of this category was to assess the value students place upon science as having an impact upon their lives. The subtest was comprised of four multiple choice questions. Generally our Manitoba grade nine students believe that science is an important subject for all students (79%), that science is a moderately difficult subject to study (58%), that science has helped to make their lives better (52%), and that the computer should be studied as a tool for use by students (59%).

The results of this subtest indicate that nearly 1/4 of all Manitoba grade nine students believe that science is a difficult subject to study. This may be a factor in the enrollment for optional science courses in grade 11 and 12. There appears to be a contradiction between 78% of the students who believe that science is an important subject for all students (#46) and the fact that 57% of the students seldom or never make an attempt to pursue science related activities outside the classroom (#44).

Category E20. Adopting Attitudes of Science. Attitudes that are more specific to science include such factors as intellectual honesty, empirical verification and a rejection of myths and superstitions. This subtest was comprised of nine multiple choice questions. Question #50 attempted to assess the students' attitude toward the treatment of scientific data. A high percentage of the students believe that data should be observed, studied and filed rather than studied and communicated (38%). Question #51 made an attempt to assess intellectual honesty by asking students what they would do with experimental data that was not consistent with standard handbook data. A discouraging 43% of the students said they would not record data until it agreed with the handbook. Thirty-eight percent of the students said they would record the data as it was evidenced by the experiment. Question #52 dealt with the four-leaf-clover superstition. Over 47% of the students do not appear to believe that there is any connection between the clover and good luck. However 22% of the grade nine students do have at least the one superstition regarding the four-leaf-clover. Questions #53-#58 asked if the student agreed, disagreed or was not sure regarding a given statement. Most students generally agreed that: 1. Great leaders need the advice of others. 2. Computers will be important to their education. 3. Scientists are responsible for the way their discoveries affect society. 4. Science should be required as a course in the public schools. 5. What scientists do affects them personally. 6. Scientists must verify their discoveries before they are communicated to the public.

The results of this subtest indicate that, in general, students in the grade 9 Manitoba science classrooms have attitudes that are consistent with scientific integrity and intellectual honesty. They are not overly superstitious and they believe that science plays an important part in today's society.

Category E21. Making Career Decisions This category was designed to assess the student's perception of need for science education when pursuing various careers. The results of this subtest should be helpful for science teachers when they informally counsel their students.

The students perceived the artist, the plumber, the baker, the hairdresser, and the musician as having careers that need minimum science education (only up to grade 10). They perceived the elementary teacher, the welder, the photographer, the farmer, and the miner as having careers that need science education in grades 11 and 12. They perceive the pharmacist, the geologist, the electrical engineer, the chemist, the astronomer, and the astronaut as having careers that require university or community college science courses.

These results indicate that the grade nine students generally perceive science education as a necessary component of the education required for most careers. Many students are not knowledgeable of the ways in which the artist, plumber, baker, hairdresser, and musician could utilize science courses beyond grade 9 to succeed best with their careers. The greatest number of students (84%) perceived the chemist as needing much science for his/her career. The greatest number of students perceived the baker as needing little science for his/her career.

F. Science and Society

This major heading is comprised of five categories, four of which were used as assessment subtests and one that was not examined. The four category subtests for this major heading are: Science in Canada (F22), Health, Nutrition and Agriculture (F23), Environment (F24), and Energy (F25). Recreation/Safety/Life Styles (F26) was not assessed. Science and Society embodies categories from both the affective and the cognitive areas, consequently, a separate analysis will be made of category F22 which is classified as affective (no right answer) and categories F23, F24, and F25 which are classified as cognitive (an acceptable correct answer is possible). Results for category F22 are reported in Table 33.

Table 33

Grade 9 - Science in Canada Results (Affective)

Category	Item Number	Percent Response to Item
F22. Science in Canada	163	47%
	164	38%
	165	25%
	166	83%
	167	66%
	168	59%
	169	86%
	170	60%
	171	77%
	172	35%

Category F22. Science in Canada. This subtest attempted to assess each student's perception of Canada's contribution to various scientific developments. While it is not unexpected to find 83% of the students perceiving Canada as an important contributor to forestry research, it is interesting to note that only 35% of Manitoba's grade nine students perceive Canada as a contributor to nuclear research. Students also perceive Canada as a minor contributor to fibre optics and genetic research.

It appears that Grade nine students in Manitoba have a very parochial perception of Canada's contribution to scientific developments. The results of this category assessment may indicate a need for a greater emphasis on Canada as a nation rather than Manitoba as a province with respect to Science and Society.

Table 34

Results of Grade 9. F. Science and Society (Cognitive)

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel
F23. Health Nutrition and Agriculture	75-79	5	2.16	1.28	43%	Satisfactory
F24. Environment	80-81	2	0.79	0.67	39%	Satisfactory
F25. Energy	173-175	3	0.91	0.84	30%	Unsatisfactory
Totals		**10**	**3.86**	**2.04**	**39%**	*

*No summary comments by Interpretation Panel

Category F23. Health, Nutrition and Agriculture. This subtest was designed to assess each student's knowledge of health, nutrition and agriculture with respect to mankind and in light of the science curriculum. Two of the questions (#78-79) combine the cognitive aspects of reading a graph with a general knowledge of human growth. Questions #75, #76, and #77 are at the cognitive level of fact but are on topics concerned with agriculture and health.

While 59% of the students knew that scurvy was related to lack of vitamin C, only 20% were aware that Triticale was a cereal grain developed at the University of Manitoba. The hectare was defined by 45% of the students. A discouraging 23% of the students were able to determine average growth from the graph when both rise (height in cm) and run (age in years) were given (question #78).

78) The following graph illustrates the relationship between a person's height in centimetres and age in years. What is the person's average growth per year between the ages of 2 and 14?

1% A) 0 cm
***24% B) 6 cm**
18% C) 12 cm
12% D) 28 cm
42% E) 72 cm

Most students selected the choice which simply gave the amount of growth. It appears that many students do not know how to respond to the term average. Question #79 also asked the student to determine average growth per year between two ages but this time height was constant. These questions were answered correctly by 68% of the students.

Category F24. Environment. This subtest was comprised of two multiple choice items. Question #80 asked the student to identify what he/she considered to be the best definition of his/her environment. The choice which was considered most correct was: "the conditions which affect my life". This choice was selected by 55% of the students. Nineteen percent of the students define their environment as "the Manitoba Climate". Given that Environmental Science is one of the six subject areas of the grade 7-9 curriculum therefore it would appear that students have difficulty with the definition of environment. The Interpretation Panel rated this subtest as Satisfactory.

Category F25. Energy. This subtest was comprised of three sentence completion items, each relating to some aspect of energy. Question #173 focused upon the conservation of energy. This question was answered correctly by 46% of the students. Question #174 focused upon the issue of oil and the world's economy. Only 9% of the students related these two factors. Question #175 asked for Manitoba's largest source of renewable energy currently in use. There were many different answers to this question, indicating perhaps some difficulty by students with the term "renewable". This question was answered correctly by 35% of the students. Over 22% of the students did not respond to question #174 or question #175. The Interpretation Panel rated this category as Unsatisfactory with no additional comments.

Summary of (F) Science and Society

The mean total correct for this major heading was 39%. While the students did relatively well on a few items there is need for much improvement in the areas of: 1. Canada's contribution to scientific development, 2. metric land measurement, 3. determining the slope of a graph curve, 4. defining the environment, 5. energy in Canada.

G. Nature of Science

Knowledge and study of past events and experiences is one of our better tools for predicting the future. A study of the history of science is characterized by the student being able to place scientific and technological knowledge and their effects upon society into the correct historical context and sequence.

This major heading is comprised of the two categories, The History of Science (G27) and The Philosophy of Science (G28). The History of Science is classified as cognitive and The Philosophy of Science is considered to be affective.

Table 35

Results of Grade 9. G. Nature of Science (G)

Categories	Items	No. of Items	Mean Raw Score	Standard Deviation	Percent	Panel
G27	82-91	10	5.32	1.80	53%	Strength

Category G27. History of Science. This subtest was comprised of 10 true or false type questions. Each question was derived from some historical aspect or personality of science which the Technical Advisory Committee felt should be common knowledge to a student who has studied the grade 7-9 curriculum. This subtest was relatively well done. No single item was below 40% and the highest percent correct was 68%. The Interpretation Panel rated this category subtest as Strength.

Category G28. Philosophy of Science. Scientists as people have personal philosophies that have materialized through their knowledge and experience with the nature of science. Science as a discipline does not allow for generalizations to be made without empirical verification. There is much stress on intellectual honesty and the inquiry mode of thinking. Through an understanding of the philosophy of science students will learn to value important aspects and limitations of science.

This subtest consisted of one long-answer explanation type question. The student was asked to state whether or not he/she believed astrology is a science and then explain why he/she believed what they believed. It was expected that the students would state several points when defending their position and that the experimental nature of science would surface somewhere in their explanation.

The results of this category did not measure up to the TAC expectation. Only 26% of the students received a correct mark for the Philosophy of Science subtest.

Summary of Grade 9 Written Results. The percent of achievement for grade 9 students on the written test categories identified as "A"-Content of Science, was 37.5%. For the categories composing subtest "B"-Processes of Science, grade 9 students attained a mean percent correct score of 42.0%. For the subtest "C"-Skills for Science, a mean score of 47.0% was recorded. For section "D"-Problem Solving and Decision Making, the mean score for grade 9 students was 46.0%.

Category "E"-Attitude Toward Science, category "F"-Science and Society and category "G"-Nature of Science comprise the affective portion of the written assessment. These results indicate that 42.% of the grade 9 students enjoy their science classes, that they enjoy working with life science most and physical sciences the least, that they believe science is an important subject for all students, that they will seldom pursue a science related activity outside the classroom, and that most believe Canada does not contribute much to nuclear research. This portion of the written assessment also revealed that the 1986 grade 9 students have a fair knowledge of the history of science and that they have difficulty relating science to society.

CHAPTER 7

GRADE 9 PERFORMANCE COMPONENT RESULTS

Performance testing for the 1986 Science Assessment Program was elected as a means of determining the level to which students had attained curriculum goals that are not possible to measure fully or are not adequately measured with the written test format. The Technical Advisory Committee determined the test categories which could not be measured fully with the written component. These categories were: Category 12 -- Skills in Using Common Laboratory Equipment, Category 13 -- Skills Associated With Safety (in the science laboratory) and Category 15 -- Following Instructions (in the science laboratory). They also determined the categories that were considered inadequately measured with the written test. These categories were: Category 5 -- Explanation of Physical Phenomena, Category 7 through 11 -- The Processes of Science, Category 14 -- Cognition, and Category 16 -- Using Inquiry Techniques.

The Performance Testing Formats. Two different and distinct formats were used for the performance testing component. These formats were called: The Station Approach and The Individual Approach. The Station Approach format was characterized by four separate stations with one student working at each station for a prescribed time (15 min.). Each student then moved to a different station for the prescribed time. This procedure continued until each student had worked at each station. Each station gave specific written instructions to the student and required the student to respond to his/her performance with a written statement providing evidence of that performance. A testing supervisor was present to explain the starting procedure, monitor the performance and to collect the written responses.

The Individual Approach format tested one student at a time. The student was given a written task by the testing supervisor. The student then attempted the required task. The testing supervisor observed the student carefully and collected the required data as the student proceeded. Four individual tasks were administered to each student. The time for each task varied but 30 minutes was the maximum time allotted per task. Generally all students had adequate time to finish their tasks.

The Station Test Performance Results. The Station Approach format was administered to 110 grade 9 students from a sample of English language, French Immersion, and French language schools during May and June of the 1986 school year. The four stations and the respective categories believed to be assessed by each station are as follows:

1. Microscopes (categories 1,2,7,8,12,15)
2. Simple Machines (categories 3,5,7,8,12,13,14,15)
3. Measurement (categories 3,6,7,8,9,14,15)
4. Earth Science (categories 3,5,7,8,9,10,12,14,15)

Summaries of the results are reported in Table 36.

TABLE 36

Results of Grade 9. Station Performance Approach

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
MICROSCOPE				**Series of questions and tasks based on use of microscope.**
	1	2-7	40%	Identified eye-piece
			55%	Identified objective.
			60%	Identified stage of microscope.
	2	12	71%	A laboratory skill requiring the student to focus the microscope well enough to determine which of three crossed threads was on top.
	3	8-12-15	74%	Students were required to reproduce an object as it was viewed through the microscope.
	4	12-2	26%	Students were required to identify either the nucleus or cytoplasm of a cell as viewed through the microscope.
	5	4-10-12	76%	Able to identify an opaque object as most difficult to view through microscope.
			59%	Able to explain why.
SIMPLE MACHINES				**Series of questions and tasks based on simple lever and pulley systems.**
	1	3-8-12 13-14	6%	Able to measure effort force for a first-class lever with spring scale to nearest 10 units.
			16%	To nearest 20 units.
	2	3-15	5%	Able to determine ideal or theoretical mechanical advantage of first-class lever given force and effort distances and resistance force.
	3	3-8-15	1%	Able to calculate the actual mechanical advantage of a first-class lever from measured data.
	4	3-15	30%	Able to evidence a general knowledge of the factors associated with M.A.
	5	3-8-12	48%	Able to measure force needed to lift object with a spring scale using a 2 pulley system.
	6	3-15	15%	Able to identify the ideal mechanical advantage of a two pulley system.
			5%	Able to calculate the actual mechanical advantage of a two pulley system.

	7	3-12-13	56%	Able to measure the force needed to lift an object with spring scale using a four pulley system.
	8	3-15	14%	Able to determine the ideal mechanical advantage of a four pulley system.
	9	3-15	5%	Able to calculate work in S.I. units grams lifted by the four pulley system and distance lifted in metres.
MEASUREMENT				**Series of tasks dealing with measuring length, volume temperature and mass, and calculating density.**
	1	3-8-12	66%	Able to measure a predetermined distance to nearest 1/2 centimetre with metre stick graduated in millimetres and record with unit.
			10%	Able to measure a predetermined distance to nearest 1/2 centimetre with metre stick graduated in millimetres.
	2	3-8-12	28%	Able to measure the volume of a liquid to ∓2 milliliters
			14%	Able to measure the volume of a liquid to ∓5 milliliters.
			3%	Measured to ∓5 mL. but no units given.
	3	3-8-12	52%	Measured temperature of a cool liquid ∓2 degrees.
			8%	Able to measure but no units given.
	4	3-8-12	70%	Measured temperature of warm liquid ∓2 degrees.
			12%	Able to measure but no units given.
	5	3-8-12	71%	Measured mass of a solid substance ∓2 grams.
			5%	Measured mass but no units given.
	6	3-8-12	70%	Measured·mass of solid substance ∓2 grams.
			5%	Measured mass but no units given.
	7	3-8-12 14-15	16%	Able to determine the volume of a metal cylinder by water displacement or measurement to ∓2 milliliters.
			2%	No units.
	8	3-8-12	66%	Able to determine mass of metal cylinder ∓2 grams.
			3%	Determined mass but no units
	9	3-9-14 14-15	5%	Able to calculate the density of the metal cylinder knowing its volume and mass.
			2%	Determined density but no units given.
EARTH SCIENCE				**Questions dealing with rock hardness, soil particle size, and water retention properties of soil.**
	1	3-9-12 15	36%	Able to identify the mineral talc by applying a given hardness scale.
			16%	Able to identify gypsum through its hardness.
			38%	Able to identify quartz through its hardness.
	2	3-7-9	81%	Able to identify clay as having smallest particle size.
			56%	Identified loam as being next in particle size.
			54%	Identified sand as having medium size particle.
	3	3-8-9 14-15	73%	Mean of % of students able to follow directions and report volume of water poured on the three soils.
			7%	No units.
			47%	Mean of % of students able to collect and measure volume of water dripped through soil.
			6%	No units.
			38%	Mean of percent of students able to calculate the volume of water remaining in soil.
			5%	No units.
	4	5-10	52%	Able to relate particle size to water retention.

Station performance approach - Microscopes. These station performance tasks were concerned with the microscope and its use. The microscope is an important part of the grade 7-9 science program and it is for this reason that it was selected as one component of the performance testing. The results of this series of tasks may be summarized as follows:

1. Three of the important parts of the microscope (stage, objective, eyepiece) were identified by an average of 52% of the students.

2. When asked to focus the microscope well enough to determine the relative position of crossed coloured threads, 71% of the students were able to do so.

3. Seventy-four percent of the students were able to look through the microscope and draw the letter "e" as they viewed it.

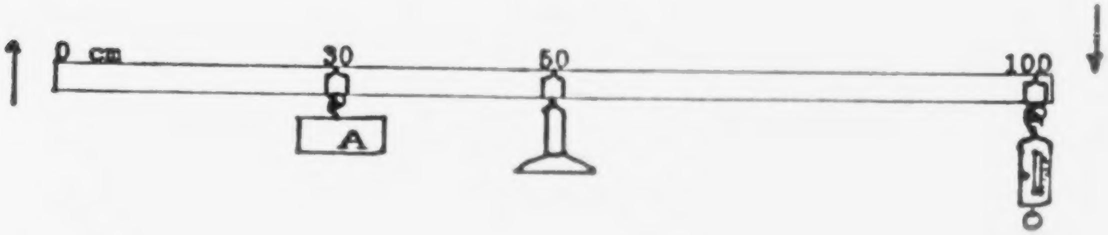
4. Item #4 of this task series involved focusing the microscope and identifying the part of a cell that the pointer was indicating. Only 26% of the students were able to name the cytoplasm or nucleus of the cell. This task required some knowledge of the cell, it appears that this may be the factor responsible for the low score.

5. Fifty-nine percent of the students were able to explain why a penny was more difficult to view through the microscope than pond water.

Station performance approach - Simple Machines. This series of tasks focused upon the first-class lever and the pulley. These particular simple machines were selected because of their relative simplicity and the fact that they are commonly used in daily life. The grade 9 curriculum includes the first-class lever as well as mechanical advantage and work done by a simple machine. The results for this station may be summarized as follows:

1. For the first task students were asked to assemble a first-class lever according to a diagram and to then measure the force needed to lift "object A" with a spring scale. Only 6% of the students were able to do this task with a reasonable degree of accuracy. Another 16% went through the right routine with a lesser degree of accuracy.

2. Given the effort distance from the fulcrum and the resistance distance from the fulcrum, students were asked to determine the ideal or theoretical mechanical advantage. Only 5% of our Manitoba grade 9 students were able to do this task, [**The ideal or theoretical mechanical advantage of the lever is ________.**].



In order to do this task the student would have to understand the terms effort and resistance, be able to read the measurements on the metre stick and be knowledgeable of the fact that the resistance to effort distance ratio is called mechanical advantage. These tasks are all within the curriculum objective expectations for grade 9.

3. Only one student was able to calculate the actual mechanical advantage from the effort force and resistance measurements. This is not unexpected given that only 6% could measure the force needed to lift object "A".

4. Task #4 for Simple Machines required the students to have enough experience with first-class levers to be able to predict either an increase or decrease in mechanical advantage if the resistance "A" is moved away from the fulcrum to the 0 position on the lever. This question was answered correctly by 30% of the students. Since the answer here is either increase or decrease, the less than 50% correct response may indicate a lack of dedication on the students' part.

5. A two-pulley system with the resistance and effort scale in place was provided for this task. Students were asked to measure the force needed to lift a 500 gram mass. The task was performed correctly by 48% of the students.

6. Students were then asked to state the ideal or theoretical and the actual mechanical advantage of the two-pulley system. Once again it appears obvious that grade 9 students are not familiar with the concept of mechanical advantage. Only 15% were able to state the ideal and 5% were able to calculate the actual mechanical advantage. Remember that nearly 1/2 of these same students have measured the effort force correctly (see #5) and the resistance is given in grams.

7. The next task required the students to measure the force needed to lift a 500-gram mass with a four-pulley system. Fifty-six percent of the students were able to correctly complete this task.

8. Only 14% of the students could determine the ideal mechanical advantage of the four-pulley system. This corresponds to the number who correctly identified the ideal M.A. of the two-pulley system.

9. The final task required the students to calculate the work done in raising a 500-gram mass 0.5 metres. To answer this question correctly the student must know that one cannot get more work out of a machine than is put into it. Few students were able to recognize the 500 grams as approximately 5 N of gravitational force and thus force times distance would equal 5 N x 0.5 m or 2.5 joules of work.

Station performance results - Measurement. For this series of performance tasks the students were asked to perform a number of measurements involving distance, volume of a liquid, temperature of a cool and of a warm liquid, mass of two objects, volume of a cylindrical solid, mass of the same cylindrical solid and lastly the density of the metal cylinder. The results of these tasks may be summarized as follows:

1. Students were given a metre stick graduated in mm and asked to measure the distance from A to B. No student reported his/her result to the nearest mm. Sixty-six percent measured correctly to the nearest 1/2 cm and an additional 10% measured but did not record any unit. If students are not able to use simple measuring tools to the degree of accuracy afforded by the tool then they are not fully cognizant of the concept of measurement. This seems to be the case for nearly all of our grade 9 students.

2. For this task students were asked to measure the volume of a red liquid in a jar given a cylinder graduated in mL. An accuracy within ± 2mL was attained by 28% of the students, another 14% attained an accuracy within ± 5 mL, but the revealing aspect of this task is that nearly 56% of the Manitoba grade 9 students could not measure the volume of the liquid with any degree of accuracy.

3-4. When asked to measure the temperature of two liquids, the temperature of the warm liquid was measured to within ± 2°C by 70% of the students. The cool liquid was measured to the same degree of accuracy by 52% of students. An average of 10% of the students measured correctly but did not use any unit to express their answer.

5-6. These tasks required the students to measure the mass of two different rocks. Rock "A" was massed correctly to within ± 2g by 71% of the grade 9 students. Rock "B" was massed to the same degree of accuracy by 70% of the students. No unit was expressed by 5% of the students.

7. Water displacement equipment was provided in order for students to measure the volume of a metal cylinder. The equipment was used successfully by less than 18% of the students. Apparently 82% of our grade 9 students do not have a working experience with water displacement as a means of determining volume.

8. This task asked the students to determine the mass of the metal cylinder used in task 7. Sixty-six percent of the students were able to do so.

9. Now that the volume and the mass of the metal cylinder have been determined the students were asked to calculate the density of the metal cylinder. Since only 17% of the students were able to determine the volume of the cylinder we cannot expect any more than this number to calculate density or the mass/volume ratio. This task was performed correctly by less than 6% of the grade 9 students.

Station Performance Results - Earth Science. This series of tasks focused upon the subject of earth science. Specifically students were asked to use a hardness scale to identify three unknown minerals, judge the particle size of three different soils, determine the percolation rate of water through the three soil samples, calculate the water retained by each soil and lastly to relate the particle size to the water retention. The results of these tasks may be summarized as follows:

1. When asked to determine hardness and to identify three different minerals accordingly 36% of the students were able to identify talc, 16% identified gypsum and 38% were able to identify quartz. Well over 50% of the grade 9 students could not use the hardness scale to identify any of the minerals. This content is considered to be a portion of the Manitoba Science curriculum.

2. For this task students were asked to judge the relative size of the particles in three different soil samples. Students were to use a magnifying glass to assist in doing this task. Clay was judged as having the smallest particle size by 81% of the students. Sand was determined to be medium by 54% of the students, and loam was determined to be "large" by 56% of the students.

3. For this task the students had to pour water through the three soil samples for a specified time and to measure the water that filtered through. They then calculated the volume of water remaining in the soil. The directions were followed correctly by 73% of the students. Forty-seven percent of the students were able to collect and measure the volume of water that filtered through the soil. The volume of water remaining in the soil was calculated successfully by 38% of the students.

4. The final task for this series required the students to make some inference that indicates a relationship between the size of the particle and the amount of water retained by the soil. Fifty-two percent of the students were able to make a correct inference for this task.

The Individual Test Performance Results

The Individual Approach format was administered to 114 grade 9 students from a sample of English language, French Immersion, and French language schools during May and June of the 1986 school year. While a certain knowledge of the cognitive factors associated with each of the four tasks could aid the student as he/she progressed with the experimental inquiry, a deliberate attempt was made to place a heavy emphasis upon the integrated processes with less emphasis upon laboratory skills and content knowledge. Each of the four tasks utilized an inquiry problem to which the student was to respond. The student was then queried as to his/her results. An attempt was made to design the four tasks at different levels of difficulty. The results for the four tasks are summarized in Table 37.

TABLE 37

Results of Grade 9. Individual Performance Approach

TASKS	ITEM	CATEGORY	CORRECT RESPONSE	COMMENTS
SUGAR LUMPS				**Problem deals with finding if there is any difference in rate at which sugar dissolves in water.**
	1	7-8-9 12-13-15-16	53%	A chemistry related problem involving solubility rate and division of solute.
	2	7-8-9 12-13-15-16	79%	A chemistry problem involving solubility rate and temperature of solvent.
	3	7-8-9 12-13-15-16	80%	A chemistry problem involving solubility rate and agitation of solution (stirring).
	4	5-9-10	47%	Two or more responses re explaining factors that affect solubility rate.

MEAL WORMS				**Problem deals with determining if meal worms prefer one kind of food over another.**
	1	7-8-9-10	87%	Defined and noted a particular preference for food.
		15-16	59%	Drew conclusions with respect to choice of food.
BOUNCING BALLS				**Problem deals with determining which of three balls bounces best on three surfaces.**
	1	16	88%	Used all 3 balls and the 3 surfaces.
			50%	Used a consistent ball release pattern.
			44%	Measured height of ball release and bounce.
			36%	Replicated the data.
	2	7-8-9	43%	Recorded height of release.
			52%	Recorded height of bounce and judged which was best ball for each of the three surfaces.
			41%	Judged which was best without measuring.
	3	5-10	81%	Judged the ping pong ball as best bouncer.
			16%	Judged the golf ball as the best bouncer.
			1%	Judged the styrofoam ball as best bouncer.
			74%	Mentioned at least one surface when explaining why they picked their ball as best bouncer.
FLYING STRAW AIRPLANE				**Task was to determine which design of straw airplane flies best.**
	1	7-8-9-10	58%	Described/drew three or more designs.
			17%	In testing indicated both dependent and independent variable.
			25%	Considered only independent variable.
			22%	Replicated flight trials.
			8%	Redesigned as a result of flight trials.
			69%	Measured extent or used another consistent basis to determine flights.

Individual Performance - Sugar Lumps. This performance task required a student to find out if there was any difference in the rate at which sugar dissolves in water. He/she was then directed to see if the size of the particle, the temperature and stirring make a difference. If a student was knowledgeable about the factors that affect the rate at which soluble substances enter into solution he/she could confirm this knowledge by adjusting his/her experimental procedure accordingly. Any student who was not aware of the factors affecting solution rate would have to structure his/her experimental design more carefully and would probably require more time. In either case the testing supervisor was present to monitor the student progress. The results of student performance for this task do not reflect a high degree of pre-knowledge with respect to solubility rate. The testing supervisor observed the experimental procedure and noted the control of variables as well as the elected dependent and independent variables. The following results were obtained:

1. Over 90% of the students checked over their materials before they began working at the task.

2. Only 40% of the students controlled temperature, volume of solvent and mass of solute when experimenting to see if size of particle of solute was a factor. Twenty-eight percent of the students controlled two of these variables.

3. Over 54% of the students controlled three variables when experimenting to see if the temperature of the solvent affected the solubility rate. Thirty-two percent of the students controlled at least two variables.

4. Sixty-four percent of the students controlled three or more variables when experimenting to see if stirring the solution affected the solubility rate.

5. The testing supervisors reported that 98% of the students appeared to be honestly trying to do the tasks.

Summary of Sugar Lumps performance. This individual performance task required the student to exhibit skill in the integrated processes of observing/classifying, identifying/interpreting/reporting data and making inferences. Skill was also required in controlling variables and in communicating experimental results. When asked to determine if factors such as size of particle, temperature of the solvent and stirring make a difference in the rate that sugar goes into solution, students did quite well with an average correct response rate of 71%. Although the supervisors report that most students worked diligently and appeared to have some knowledge of controlling variables only 16% of the students were able to explain three factors that influence solubility rate. Note that this occurred immediately after a reasonably high success rate at determining the same three factors through experimentation. Thirty-one percent of the students could name two factors, 36% could name one factor and 17% did not report any of the factors that influence solubility rate. It seems that most students generally have some idea as to how to proceed in the science laboratory but it appears that most have difficulty explaining what they are doing.

Individual Performance - Meal Worms. This individual task was quite open-ended, it simply asked the student to do experimental research to see if meal worms prefer one kind of food over another. The student was given worms, several types of food, a metre stick, tweezers and an open dish. Each student was observed by the testing supervisor to determine the degree to which he/she:

1. organized the task
2. controlled variables
3. used an acceptable experimental method
4. was able to report the results.

The supervisors generally agreed that the students were serious about doing this task. A majority of the students (94%) experimented with at least three different foods but only 11% controlled the amount given each worm. Slightly more than 40% controlled the opportunity for each worm to reach the food and 94% did not seem to feel it was important to control the time involved. Most of the students (83%) used more than one worm. A worm preference for a particular food was reported by 87% of the students, the preference was defined and noted. Conclusions regarding the food choices were made by 59% of the students. The supervisors reported that 64% of the students did some degree of planning regarding their approach, before attempting the experiment.

Summary of Meal Worms performance. This particular task, while rather simple in structure, allowed for the assessment of the student's ability to organize and carry through an experimental task. The results indicate that Manitoba Grade 9 students do not possess the necessary background to accommodate the planning stage for an experiment, but they do have reasonably good skills for "trying things as they proceed". This task provided evidence that students seem to have an awareness for controlling variables even though they have difficulty verbalizing their meaning and explaining the role of the variable in the inquiry procedure.

Individual Performance - Bouncing Balls. This performance task was more complicated than either the Sugar Lumps or the Meal Worms task. It involved determining the best bouncing ball given three different surfaces and three different balls. Although the students seemed to be controlling the combination of three balls and three surfaces (75% reported by the testing supervisors) 74% of the students reported their results with respect to at least one surface. A consistent release pattern was used by 50% of the students and 44% measured the height of both release and bounce. A further 15% measured only one or the other. Most students did not state at the outset that it was necessary to drop a ball on a given surface more than once (64%). However, supervisors reported that 75% of students did in fact replicate their trials for each ball and surface. Data on the height of the bounce were recorded in the chart (which was provided to each student) by 52% of the students. Although most students reported an overall best bouncing ball they did not generally recognize the 3x3 data collection requirements.

Summary of Bouncing Balls Performance. It is encouraging to see Grade 9 students using acceptable measuring techniques when the opportunity arises. The discouraging aspect of this task was the degree to which students organized the data which they collected. Although a chart was provided with the three surfaces listed on it only 52% systematically recorded bounce heights for all balls on all surfaces. The explanations reported by students as to why they picked the best bouncing ball indicate that most students did recognize a portion of the possible combinations of data regarding the three surfaces and the three balls. This information coupled with the fact that only 36% indicated a need to replicate the bounce data and with the low percentage (50%) who used a consistent release pattern, indicates that Manitoba grade 9 students generally had some difficulty in controlling variables and applying good experimental and laboratory skills.

Individual Performance - Flying Straw Airplanes. This task was the most open-ended of the four. It provided students with the opportunity to combine creativity with experimental procedure. Each student was asked to determine a paper straw airplane design that would fly best. Drawings of three different planes which other students had used were provided as examples to help the testing student get started. Each student was provided with paper, masking tape, paper clips and paper straws. The expectation for this task was that students would design, build, test, and then redesign and test in light of the first trial. Each student was asked to keep a record of his/her work.

Three different designs, many similar to the given drawings, were described or drawn by 58% of the students. Few students (17%) reported the method they would use to test the quality of flight produced by their designs in terms of both a dependent and an independent variable. An independent variable only was reported by 25% of the students and 6% reported a dependent variable only (usually the distance of the flight). Over one-half of the students who performed this task (52%) did not report any testing method. As with other individual performance tasks, few students (22%) replicated any given trial. Redesign as a result of a trial flight was accomplished by 8% of the students. Most students judged the quality of a flight by some method other than measuring (61%). No consistent basis for judging quality of flight was indicated by 18% of the students. The testing supervisors judged the student's use of controls for this task as: none - 18%, poor - 51%, good - 26%. Generally the supervisors observed that the testing students did not understand the need to experiment in order to determine the best flying plane. The supervisors also reported that the task was taken seriously by nearly all students.

Summary of Flying Straw Airplane Performance. Students created many interesting designs for paper straw airplanes but they provided little evidence of scientific method and experimental controls for determining how well their creations would fly. These factors coupled with the lack of replicated trials and the lack of any organized data collection are evidenced as deficient factors in the student's background for performing inquiry investigations.

Summary of Individual Performance Tasks. Each of the four individual performance tasks required knowledge of the integrated processes involving: 1) perceiving the problem, 2) organizing the experimental design, 3) collecting the data, 4) interpreting the data and 5) communicating the results. The Grade 9 students appeared to accept each task with a high degree of purpose. They followed directions quite well and have some knowledge of inquiry. Their performance however, evidences consistent deficiencies most of which are embodied in the integrated process called "Experimentation". They did not appear able to design their own experimental procedure or to organize their data in a manner that would allow for accurate communication of results. They had some difficulty handling variables and generally seemed to be unfamiliar with common inquiry techniques such as repetition of trials and the use of controls. The students seemed to be able to handle the mechanical laboratory skills required by the tasks with a reasonable degree of proficiency.

Summary of Performance Tasks

The results of the individual and station performance tasks revealed a number of significant factors concerning student laboratory skill, safety skill, conceptual knowledge, and process skill. Generally Grade 9 students are familiar with and know how to use their laboratory equipment. However, there appears to be a definite lack in ability to use laboratory measuring equipment to the full extent of its measuring capacity, as evidenced by the low percentage of accuracy attained by students. Generally, students seem to have difficulty with any measurement that involves a calculation. (Over 55% did not do the simple subtraction required in item #3 of earth science and 93% could not calculate work or density from measurement data.) There was little or no evidence of students not using correct safety procedures. Students appeared to have the greatest difficulty with task items that required some conceptual information that would normally be taught prior to the doing of the task e.g. the fact that the force and effort distance relationship for a first-class lever constitutes a way of determining mechanical advantage, or the number of strands supporting the moveable block determines the ideal M.A. for a pulley system. The individual tasks provided evidence that students are very willing to attempt laboratory hands-on type tasks, but, they are often lacking in the knowledge background needed to proceed effectively with the task. In some cases students seem to be lacking in their ability to draw conclusions and to make inferences from available data. They have difficulty in controlling variables, organizing their data and repeating their trials.

Conclusions and Recommendations for Grade 9 Written and Performance Components

The following conclusions and corresponding recommendations are made in light of both the written and performance results for the Grade 9 student assessment.

Conclusion Statement #1

The level of retention for the lower cognitive science content (facts and terminology) by Grade 9 Manitoba school students is low enough to be a cause for concern (42% and 34% respectively). There are educators who would say that facts and terminology are only memory items and perhaps not important enough to warrant consideration. However it is difficult to imagine how a science student would be able to follow laboratory directions and to communicate the results of his/her experimentation without full knowledge of the facts and terminologies of science.

Recommendation Statement #1

That all teachers of Grade 9 science conduct frequent, formative assessments to determine student knowledge of the facts and terminologies of the current science being taught. Where lack of knowledge is found, remedial steps should be taken. While lack of retention may be due to a number of factors, student motivation being an important one, it is expected that student ability to remember the facts and terminologies of science will improve with more evaluation and more rehearsal.

Conclusion Statement #2

The unsatisfactory performance rating received by the Grade 9 students in the higher cognitive areas is low enough to be a cause for concern. Explaining a theory of science (13% able to make two statements relative to the Big-Bang and Kinetic-Molecular theories); ability to explain physical phenomena

(27% correct); and the ability to elaborate on current trends related to science (26%) illustrates this. While the Grade 9 students did relatively well on concepts and their relationships, which is a reasonably difficult area, they were not able to indicate an acceptable level of knowledge and ideas associated with the concepts.

Recommendation Statement #2

It is recommended that teachers of Grade 9 science make a deliberate attempt to relate the facts and terminologies of science to the larger conceptual scheme embodying them, and wherever possible to integrate concepts into larger, more encompassing theories. While this is done by many science teachers, the assessment results indicate that more emphasis must be given to this area.

Conclusion Statement #3

The relatively low student assessment results may be reflected by the data from a separate survey of grades 7-9 science teachers conducted by Manitoba Education which indicated that teachers had little formal science training. Regardless of a teachers' ability to relate to students, the teacher must possess a knowledge background that will allow for accurate specific explanations and appropriate analysis and synthesis of the concepts to be learned. The cognitive level of the science at the Grade 7-9 level is too sophisticated for teachers who do not have appropriate science course work and laboratory experience.

Recommendation Statement #3

Teachers should not be expected to successfully teach grade 7-9 science until they have appropriate course work and laboratory experience. Three steps are necessary to ensure that only qualified teachers will instruct our Manitoba school children in grade 7-9 science.

1. Any new teacher hired to teach science should have a minimum of 18 credit hours, including laboratory work, covering two or more recognized science areas.

2. University courses, workshops and short courses should be provided for teachers who need them and teachers in need must be encouraged to take such courses, particularly with decreasing school enrollments and the need for the teachers to teach a wide range of subjects.

Conclusion Statement #4

While the Grade 9 students did reasonably well in the section designated for laboratory safety skills, (58%), this is an area that requires an extremely high performance rate. Teachers and schools cannot afford to have 22% of their students not reporting a laboratory injury immediately after it occurs.

Recommendation Statement #4

While safety in the science laboratory has not been a problem to date, the assessment results indicate that there is need for a greater emphasis upon science classroom and laboratory safety. Short-term workshops and/or the concept of safety should be built into any new science programs for teachers.

Conclusion Statement #5

Assessment results from both the written and performance component indicate that Grade 9 students have difficulty in identifying cause and effect variables and in controlling variables in an inquiry investigation or experiment.

Recommendation Statement #5

While the grade 7-9 curriculum has much potential for generating inquiry situations that could give students practice in handling experimental variables, the actual investigations are not "laid on" in the curriculum. Teachers presently rely upon the textual material to provide the needed inquiry investigations and this may not be sufficient. It is recommended that inquiry material be provided in a systematic mode in context with whatever concept is being taught. A single text that is consistent with the curriculum objectives and used universally throughout the province would do much to rectify this deficiency.

Conclusion Statement #6

The curriculum calls for a process approach with emphasis on observing, classifying, communicating, measuring, hypothesizing, defining operationally, controlling variables, collecting and interpreting data, inferring, modelling and theorizing. Whereas, students do well with some processes of science, they have a degree of difficulty with the process of hypothesizing and with the integrated processes generally.

Recommendation #6

There is an immediate need to review the grade 7-9 science curriculum in order to place more emphasis upon students designing simple experiments.

Conclusion Statement #7

The Grade 9 assessment results indicate that while students exercise care and are capable of demonstrating a number of laboratory skills they do not seem able to relate the cognitive aspects that are to be learned in the classroom to the inquiry investigation in the laboratory, e.g., students can manipulate the equipment for a first class lever; however, they have difficulty solving problems related to the lever. As well, students do very poorly in such experimental techniques as repeated data collection and organization of data collected.

Recommendation Statement #7

It is recommended that the present curriculum be altered in a manner that will provide for a much greater emphasis for inquiry investigations relative to all significant concepts of the grade 7-9 science course of study.

Conclusion Statement #8

There were adequate measurement and measurement related questions in the written and performance assessment to provide a reliable estimate of student abilities in this area. The results indicate that students are not receiving instruction, or not retaining instruction in the use of dimensional analysis when solving problems requiring the use of SI dimensions. In some cases the difficulty is with knowledge of the SI terminology but in most cases the students simply do not seem aware of the importance of dimensions.

Recommendation #8

In order to help alleviate the indicated deficiency in the use of dimensions and the appropriate SI units it is recommended that remediation be implemented to overcome this problem by providing workshops and curriculum supplementary materials for teachers. Also it is recommended that a greater effort be made to integrate the teaching of SI units with other subject areas.

Conclusion Statement #9

The Grade 9 assessment results indicate distinct differences in the student's ability to respond to questions related to particular subject areas. Assessment results in Earth Science and Physics were noticeably lower than those in Chemistry, Space Science, Life Science, and Environment.

Recommendation Statement #9

The intent of the Grade 7-9 Science Curriculum is that each subject area is to be given equal attention in order that our Manitoba students will have diverse but significant exposure to the major areas that constitute "science". Students who consistently miss out on either or both of their Earth Science and Physics instruction are bound to be penalized with respect to their future science endeavors. Consequently, it is recommended that some method of course supervision, either by an administrator or science department designate, be instigated to assure that at least adequate time be given to instruction in each area of science and that proper evaluation occur in each of the areas.

Conclusion Statement #10

The assessment results indicate that grade 9 students generally have a positive attitude toward science. They also indicate, however, that students are quite limited in their perception of Canada's contribution to developments in science.

Recommendation Statement #10

It is recommended that the Science and Society components of science instruction be given emphasis in the form of better integration with the curriculum content. There is evidence to indicate that greater retention occurs when factors such as Canada's contribution to science developments occur in context with particular concept instruction.

CHAPTER 8

SCIENCE COMPARISON TESTING 1980-85

The 1986 Manitoba Education Science Assessment Program included a comparison testing component. The objective of this component was to determine any change which may have occurred in student achievement in science from the time of the 1980 Provincial Science Assessment to the occasion of the 1986 assessment. Indirectly, the results of this comparison test should reflect on any change which may have occurred in the quality of instruction in science during the comparison period.

Due to the fact that the 1986 assessment was designed for different grade levels and employed a different conceptual and testing format from the 1980 instrument, distinct tests, consisting of items selected by the Technical Advisory Committee (TAC) directly from the 1980 assessment, were utilized for the comparison component. In order to make the comparison as statistically valid as possible the comparison tests were given to the same grade levels (5, 8, & 11) at about the same time of year (November 1985) as the 1980 assessment. The size of the 1985 testing samples, in terms of numbers of pupils and numbers of schools tested, was smaller than in 1980. The sampling design used in 1985 was a stratified cluster design. More information on the sampling design can be found in Appendix 1.

It should be noted that the present curriculum guides, "Science Grades K-6" and "Science Grades 7-9", were in place in the Manitoba schools in 1980. Consequently there was no major curricular change for Grades 5 and 8 for the comparison period. The Grade 10 science curriculum did undergo some change during the comparison period and this may have had some influence on the Grade 11 comparison results. Tables 38, 39, and 40 present means ($\bar{X}$) and standard errors of the mean ($S(\bar{X})$).

Table 38
Grade 5 Comparison Results

Test Area	No. of Items	1980(n=1425)			1985(n=708)*		
		$\bar{X}$	Average % Correct	$S(\bar{X})$	$\bar{X}$	Average % Correct	$S(\bar{X})$
Nature of Science	3	1.721	57%	.0250	1.669	56%	.0693
Processes of Science	6	3.926	65%	.0365	3.866	64%	.0933
Astronomy	3	1.805	60%	.0231	1.839	61%	.0688
Earth Science and Weather	6	2.472	41%	.0325	2.544	42%	.1263
Physical Science	9	3.898	43%	.0464	3.926	44%	.1990
Life Science	8	3.973	50%	.0473	4.007	50%	.1804
TOTAL		17.80		.1375	17.85		.6234

*d.f. = 18

Nature of Science: The degree of change in achievement experienced by grade five students over the five-year comparison period for the topic "Nature of Science" was significantly lower (.05 level) in 1985 than in 1980. The mean correct scores were 1.67 (56%) and 1.72 (57%) respectively. Test items for this topic focused on scientific approaches to observations and data collection as well as the non-capricious nature of science.

Processes of Science: Grade five students achieved a mean score of 3.86 (64%) in 1985 for the 6 items composing this topic. The mean score for this topic in 1980 was 3.92 (65%). This difference is not significant at the .05 level and indicates that grade five achievement for "Processes of Science" did not change over the 5-year comparison period. The degree of attainment (64-65%) is considered to be satisfactory. The test items for this topic focused on the basic processes of observation and measurement.

Astronomy: The 1985 mean score correct for the 3 test items on the topic "Astronomy" was greater than the 1980 mean score, 1.84 and 1.81 respectively. This difference is not significant at the .05 level. The degree of attainment (61-60%) is considered to be satisfactory. The items comprising this topic focused on the position and size of objects in space.

Earth Science and Weather: The mean score correct for the 6 items on this topic was greater in 1985 than in 1980, 2.54 (42%) and 2.47 (41%) respectively. While this difference is significant at the .05 level and indicates some positive change, it should noted that the degree of attainment was relatively low and did not exceed 42% correct. The items comprising this topic focused on temperature, erosion and weathering.

Physical Science: The Grade 5 students answered 3.93 or 44% of the 9 items comprising this topic correctly on the 1985 comparison test. The mean correct score in physical science for these same items on the 1980 assessment was 3.90 or 43%. Although the 1980 mean score was judged to be satisfactory by the Interpretation Panels, the score was relatively low and has remained so during the comparison period. The items comprising this topic focused on force, electricity, magnetism, light, sound, and states of matter.

Life Science: Both the 1985 and the 1980 testing samples answered approximately 50% of the 8 items comprising this topic correctly. While this degree of achievement is considered to be satisfactory, these results indicate little or no positive change for instruction in life science during the 5-year comparison period. The questions composing this topic focused on body systems, cells, photosynthesis ecological succession and reproduction.

A summary of the 1985 comparison tests for Grade 5 science students in the English, FL1 and FL2 Manitoba schools, indicates that there has been no significant change, at the .01 level, in the achievement during the 5-year comparison period. At the .05 level of significance there was a loss or negative change for the topic, "Nature of Science" and a gain or positive change for the topic, "Earth Science and Weather". All other topics remained unchanged at this level of significance.

A summary of the grade five comparison test results indicates a degree of positive change in "Earth Science and Weather". It should be noted however, that the mean student achievement for both this topic and "Physical Science", in terms of percent correct, continued to be low (41-44%). The highest percent correct for any topic on the comparison test was 64% for the topic "Processes of Science". Although this is a reasonably good mean score it has not changed significantly over the 5-year comparison period and may indicate a somewhat static condition with respect to the curriculum and to the quality of instruction in grade five. This assumption may also be reasonable for the topics, "Astronomy" and "Life Science", which remained essentially unchanged at 64% correct and 50% correct respectively, during the comparison period.

The phrase which best represents the results of the 1985 Grade 5 comparison test is: **"Little or no change"**. The level of science achievement in Grade 5 was inadequate in 1980 and does not appear to have improved to any significant degree since that time. When the results of the written comparison test are considered in light of the 1986 Grade 6 written and performance science assessment components there is a high degree of consistency among the topics where achievement was low. Together these data should provide motivation for the establishment of a unified program to improve the quality of science instruction in the elementary schools of Manitoba.

Table 39
Grade 8 Comparison Results

Test Area	No. of Items	1980(n=1395)			1985(n=777)*		
		$\bar{X}$	Average % Correct	$S(\bar{X})$	$\bar{X}$	Average % Correct	$S(\bar{X})$
Weather	11	5.657	51%	.0577	5.221	47%	.1992
Physical Science	13	6.642	51%	.0713	6.188	48%	.1692
Life Science	10	5.065	51%	.0584	4.791	48%	.2004
Process	12	6.584	55%	.0693	6.206	52%	.1851
Safety	4	2.084	52%	.0297	1.945	49%	.0748
Nature	3	1.823	61%	.0272	1.634	54%	.0902
TOTAL		27.85		.236	25.99		.799

* d.f. = 12

Weather: There were 11 items associated with the topic "Weather" on the Grade 8 comparison examination. These questions focused generally on seasons, evaporation, dew-point, Sun's rays and air pressure. The mean score correct for the 11 items in 1980 was 5.657 or 51%. In 1985 the mean score correct was 5.221 or 47%. This difference is significant at the .01 level and indicates that the Grade 8 students achieved significantly lower (4%) in 1985.

Physical Science: Grade eight students who wrote the 1985 comparison examination received a mean score correct of 6.188 or 48% for the 13 items associated with physical science. In 1980 Grade 8 students achieved a mean correct score of 6.642 or 51% for the identical questions. This difference (3%) is significant at the .01 level and indicates that Grade 8 students performed significantly lower for the topic "Physical Science" in 1985. The items comprising the physical science topic focused mostly on light, electricity, force, magnetism, molecular motion and chemical change.

Life Science: The comparison examination utilized 10 items for the topic "Life Science". In 1980, Grade 8 students answered 51% of these items correctly for a mean score of 5.065. In 1985, Grade 8 students answered 48% of these items correctly for mean score of 4.791. This difference (3%) is significant at the .01 level and indicates that Grade 8 students achieved significantly less well in 1985. The items comprising the topic "Life Science" focused primarily on cell structure and function, the role of green plants in photosynthesis, and characteristics of animals.

Process of Science: In 1980, Grade 8 students answered 55% of the 12 items on this topic correctly for a mean score of 6.584. In 1985 Grade 8 students answered 52% of these items correctly for a mean score of 6.206. This difference (3%) is significant at the .01 level and indicates that in 1985 Grade 8 students achieved significantly less on the topic, "Processes of Science". This topic focused primarily on the integrated process of experimentation, prediction, hypothesizing, and problem solving.

Safety in Science: There were 4 items on this topic in the 1985 comparison examination. Grade 8 students answered 49% of these items correctly and achieved a mean score of 1.945. In 1980, Grade 8 students answered 52% of these items correctly for a mean score of 2.084. This difference (3%) is significant at the .01 level and indicates that Grade 8 students performed less well in 1985 on the topic, "Safety in Science". The items comprising this topic focused primarily on laboratory procedure dealing with heating materials.

Nature of Science: The three items comprising this topic focused on making observations, collecting data and the non-capricious nature of science. Students answered 61% of these items correctly in 1980 for a mean score of 1.823. In 1985, Grade 8 students answered 54% of these items correctly for a mean score of 1.634. This difference (7%) is significant at the .01 level and indicates that in 1985 Grade 8 students performed less well on the topic "Nature of Science".

In summary it may be noted that Grade 8 students performed less well (at the .01 level of significance) on all topics comprising the 1985 comparison examination.

The magnitude of achievement ranged from 47% correct on "Weather" to 54% correct on, "Nature of Science" with an average achievement of 49%. Students achieved least in the topics of weather and physical science, 47% and 48% respectively. These results are consistent with, but higher than, the grade five achievement on these two topics, whereby students received mean scores of 42% and 43% respectively. While Grade 8 students performed somewhat better than grade five students on these two topics the results for both grade levels are less than desirable and reinforce the need for a unified program to upgrade the quality of science instruction in Manitoba Grade 6 to Grade 9 schools.

Table 40
Grade 11 Comparison Results

Test Area	No. of Items	1980(n=1395) $\bar{X}$	Average % Correct	$S(\bar{X})$	1985(n=793)* Average % Correct	$\bar{X}$	$S(\bar{X})$
Weather	4	1.849	46%	.0321	41%	1.624	.0199
Astronomy	3	1.675	56%	.0244	54%	1.625	.032
Earth Science	4	2.152	54%	.0314	58%	2.330	.0433
Electricity and Magnetism	4	2.451	61%	.0332	57%	2.295	.0677
Force, Work, Energy	5	2.159	43%	.0349	42%	2.078	.0381
Heat & Temperature	3	1.650	55%	.0246	48%	1.439	.0272
Light	4	2.059	51%	.0312	44%	1.767	.0732
Structure of Matter	4	2.111	53%	.0362	54%	2.151	.0639
Physical Properties	3	1.494	50%	.0279	52%	1.558	.0591
Chemical Properties	7	3.113	44%	.0486	43%	3.036	.0910
Life Science	15	7.631	51%	.0950	52%	7.779	.1829
Nature of Science	5	3.764	75%	.0330	76%	3.789	.0793
Processes of Science	3	1.700	57%	.0257	55%	1.655	.0532
Safety in Science	4	2.204	55%	.0311	60%	2.417	.0471
Laboratory Techniques	3	1.412	47%	.0275	47%	1.413	.0231
TOTAL		37.43		.318		36.96	.683

* d.f. = 7

The Grade 11 English, FL1 and FL2 comparison examination included more separate topics than either the grade five or Gráde 8 test. Weather, Astronomy and Earth Science were considered independently and the physical science was sub-divided into four separate topics in physics and three in chemistry. The physics topics were: 1. Electricity and Magnetism, 2. Force, Work and Energy, 3. Heat and Temperature, and 4. Light. The three topics in chemistry were: 1. Structure of Matter, 2. Physical Properties, and 3. Chemical properties. Life Science remained a single topic of 15 items and Nature of Science, Safety in Science and Laboratory Techniques were considered individually.

Weather: In 1985, Grade 11 students answered 41% of the 4 items correctly for a mean score of 1.624. In 1980, Grade 11 students answered 46% of these items correctly for a mean score of 1.849. This difference (5%) is significant at the .01 level and indicates that Grade 11 students did less well on the topic "Weather" in 1985.

Astronomy: In 1980, Grade 11 students answered 56% of the 3 items comprising this topic correctly. In 1985 they answered 54% correctly. The mean score for 1980 and 1985 was 1.675 and 1.625 respectively. This difference is significant at the .05 level and indicates that Grade 11 students did less well in 1985 for the topic "Astronomy".

Earth Science: In 1985 Grade 11 students answered 58% of the 4 items comprising this topic correctly. In 1980 Grade 11 students answered 54% of these items correctly. The mean score for 1985 and 1980 respectively was 2.330 and 2.152. This difference is significant at the .01 level and indicates that Grade 11 students did better on the topic "Earth Science" in 1985.

Electricity and Magnetism: Grade eleven students answered 61% of the 4 items comprising this topic correctly in 1980. In 1985 they answered 57% of these items correctly. The mean score for 1980 and 1985 respectively was 2.451 and 2.295. This difference is significant at the .01 level and indicates that Grade 11 students did less well on "Electricity and Magnetism" in 1985.

Force, Work and Energy: This topic consisted of 5 items. Grade eleven students answered 2.159 or 43% of these items correctly in 1980. In 1985 they answered 2.098 or 42% of the items correctly. This difference is significant at the .05 level and indicates that Grade 11 students did less well on the topic "Force, Work and Energy" in 1985.

Heat and Temperatures: There were three items on this topic in the comparison examination. Grade eleven students answered 1.650 or 55% of the items correctly in 1980. In 1985 they answered 1.439 or 48% of the items correctly. This difference is significant at the .01 level and indicates that Grade 11 students did less well on the topic "Heat and Temperature" in 1985.

Light: There were 4 test items on this topic. Grade eleven students answered 2.059 or 51% of these items correctly in 1980, and 1.767 or 44% of the items correctly in 1985. This difference is significant at the .01 level and indicates that this grade level student, generally, is doing less well on the topic "Light", in 1985.

Structure of Matter: Of the 4 items which comprised this topic, Grade 11 students answered 2.111 or 53% correctly in 1980, and 2.151 or 54% correctly in 1985. This difference is not significant at the .05 level and indicates that there was little or no change in achievement by Grade 11 students, on the topic "Structure of Matter", in 1985.

Physical Properties: Grade eleven students answered 1.494 or 50 % of the 3 items comprising this topic correctly in 1980. In 1985 this grade level student answered 1.558 or 52% of these items correctly. This difference is significant at the .05 level and indicates that Grade 11 students did somewhat better on the topic "Physical Properties", in 1985.

Chemical Properties: This topic consisted of 7 items. In 1980 Grade 11 students answered 3.113 or 44% of these items correctly. In 1985 this grade level student answered 3.036 or 43% of these items correctly. The degree of attainment for this topic was less than desirable in 1980 and remained so in 1985. The difference in score over the 5-year comparison period did not significantly change for the topic "Chemical Properties".

Life Science: This was a large topic consisting of 15 test questions. Grade eleven students answered 7.631 or 51% of these questions correctly in 1980 and 7.779 or 52% of these questions correctly in 1985. This difference is not significant at the .05 level and indicates that Grade 11 students did not change in achievement for the topic "Life Science" between 1980 and 1985.

Nature of Science: Grade eleven students answered 3.764 or 75% of the 5 items comprising this topic correctly in 1980. In 1985 this grade level student answered 3.789 or 76% of these items correctly. The degree of attainment for this topic is desirable. The difference in score, over the 5-year comparison period, is not significant at the .05 level and indicates that there was no change in achievement for the topic "Nature of Science".

Processes of Science: Grade eleven students answered 1.700 or 57% of the 3 items comprising this topic correctly in 1980 and 1.655 or 55% correctly in 1985. This difference is not significant at the .05 level and indicates no change in achievement for Grade 11 students between 1980 and 1985 for the topic "Processes of Science".

Safety in Science: Of the 4 items comprising this topic, Grade 11 students answered 2.204 or 55% of them correctly in 1980. In 1985 this grade level student answered an average of 2.417 or 60% of the items correctly. This difference is significant at the .01 level and indicates that Grade 11 students are better able to respond correctly to questions related to safety in science in 1985 than they were in 1980.

Laboratory Techniques: There were 3 questions on this topic. In 1980, Grade 11 students answered 1.412 or 47% of the items correctly. In 1985, this grade level student responded correctly to 1.413 or 47% of the items. These results are nearly identical and indicate a consistently low level of achievement for the topic "Laboratory Techniques" by Grade 11 students between 1980 and 1985.

A summary of the 1985 comparison test for Grade 11 indicates that this grade level student performed better in 1985 than in 1980 on the topics Earth Science, Physical Properties, and Safety in Science. They performed less well in 1985 than in 1980 on the topics Weather, Astronomy, Electricity and Magnetism, Force, Work and Energy, Heat and Temperature, and Light.

The level of attainment by these students was 48% or less on the topics of Weather, Force Work and Energy, Heat and Temperature, Light, Chemical Properties, and Laboratory Techniques.

Recent changes in the Grade 10 science curriculum which recommend topics in Life Science in lieu of the more traditional I.P.S. (Introductory Physical Science), and which require fewer investigative laboratory experiences than did the I.P.S., may have been partially responsible for these results. It should be noted that the topics relating generally to the physical sciences, and the earth sciences (weather) are areas where Grade 11 students are consistently low achievers and in many cases have regressed over the 5-year comparison period.

SUMMARY:

The comparison testing component of the 1986 Manitoba Education Science Assessment Program was actually a "mini assessment" which used the 1980 results as base-line data for comparison to the 1985 results. The test items for the comparison were all multiple-choice questions which were taken directly from the 1980 assessment instrument.

Analysis of the comparison results indicates the following:

1. Grade 5 achievement in science in 1985 is comparable to achievement in 1980.

2. Grade 5 achievement was highest for the topic "Processes of Science" (64%) and lowest for the topics "Earth Science and Weather" (42%), and "Physical Science" (43%).
3. Grade 8 achievement regressed over the five-year comparison period for all topics that were tested.

4. Grade 8 achievement was highest in the topic "Nature of Science" (54%), and lowest in the topics "Weather" (47%) "Physical Science" (48%), and "Life Science" (48%).

5. Grade 11 achievement in science improved for the topics: "Earth Science", "Physical Properties", and "Safety in Science".

6. Grade 11 achievement in science was static for the topics: "Structure of Matter", "Chemical Properties", "Life Science", "Nature of Science", "Processes of Science", and "Laboratory Techniques".

7. Grade 11 achievement in science regressed for the topics: "Weather", "Astronomy", "Electricity and Magnetism", "Force, Work and Energy", "Heat and Temperature", and "Light".

8. Grade 11 achievement for all topics where regression occurred, other than "Astronomy" and "Electricity and Magnetism", was between 40% and 48%. Achievement for "Chemical Properties", a topic which remained static, was 43%.

9. Grade 11 achievement was 55% or greater for the topics: Earth Science, Electricity and Magnetism, Nature of Science, Processes of science, and Safety in Science.

10. There is a trend throughout Grades 5, 8, and 11 toward low achievement and regression for the topics related to the physical sciences and weather.

CHAPTER 9

SCIENCE TEACHER SURVEY

GRADES 1 - 6

INTRODUCTION

The Teacher Survey Questionnaire was designed to collect information which would assist in providing a better overview of provincial student performance in science and to provide a better understanding of the circumstances and conditions which relate to the teaching of science in Grades K - 6 classrooms.

The information obtained from teachers will not explain specific problems or issues but will reflect on the Grade K - 6 science program and its adaptation by teachers.

The Survey

The questionnaire was developed by various committees and persons associated with the Science Assessment. The final draft of the questionnaire was completed in May, 1986, and mailed to teachers June 12, 1986. A computer program was prepared to select a random sample of two hundred teachers teaching science in Kindergarten to Grade 6. The questionnaires were mailed to teachers with the following grade population distributions.

Table 41

Grade	Actual number in sample
K	11
1	186
2	188
3	174
4	175
5	172
6	171
TOTAL	**1077**

Because of teachers teaching in two or more grades, the original sample of two hundred teachers per grade was reduced to the totals provided in Table 41. Each questionnaire was mailed to the teacher's home address and each teacher was requested to complete the questionnaire for a specific grade level. After the initial mailing of the questionnaires to teachers, a follow-up letter was mailed to teachers who did not respond to the questionnaires. The results of the Science Survey Questionnaire returned are as follows:

Table 42

Grades	Questionnaires Mailed	Initial Returns	Returns after reminder	TOTAL Returned
K	11	1	3	4
1	186	79	32	111
2	188	55	40	95
3	174	59	35	94
4	175	60	38	98
5	172	55	32	87
6	171	52	36	88
TOTAL	**1077**	**361**	**216**	**577**

Because of the low number of teachers in the Kindergarten sample, it was necessary to exclude the Kindergarten teachers in the Questionnaire results. The final return of questionnaires by all respondents was 56% Five percent of the questionnaires were not completed because of persons not at the specified address or were not teaching the specified grade level.

Table 43

Responding at grade		Teaching science at grade									
		K	1	2	3	4	5	6	7	8	9
1	n %	2 2%	82 76%	21 19%	6 5%	3 3%	4 4%	2 2%	1 1%	1 1%	0
2		5 5%	21 22%	75 79%	16 17%	2 2%	2 2%	1 1%	2 2%	2 2%	0
3		2 2%	5 5%	11 12%	71 76%	15 16%	6 6%	5 5%	2 2%	1 1%	0
4		1 1%	4 4%	5 5%	15 15%	75 77%	15 15%	8 8%	3 3%	3 3%	1 1%
5		0 0	0 0	0 0	1 1%	11 13%	67 77%	19 22%	2 2%	2 2%	0
6		1 1%	2 2%	2 2%	2 2%	5 6%	17 19%	64 73%	5 6%	3 3%	2 2%

As indicated earlier in the Report, teachers were asked to complete the survey at the specific grade level of Grades K - 6. However, the teachers were also asked to identify what other grade levels they taught science. Table 43 illustrates the relationship of the respondent's survey questionnaire grade identification with that of other grades which the respondents were teaching.

NOTE: The following pages discuss results of questionnaires from teachers in Grades 1 - 6 only because the number of Kindergarten respondants was too small for valid analysis.

SUMMARY OF SCIENCE TEACHERS SURVEY QUESTIONNAIRE RESULTS GRADES 1-6

I A. The "importance" of Curriculum Guides were considered by the respondents to be "Important or Very Important" on the scale (high 1 - low 11) for the following factors on meeting program objectives:

High — Objectives

1.5 - Importance of developing curiosity and creativity

1.5 - Importance of developing the skills and processes of investigation such as observing, classifying, and hypothesizing

3 - Importance of developing social skills such as cooperation or sense of responsibility, and the ability to communicate

4 - Importance of developing problem solving skills such as clarifying the problem, designing possible solutions and the ability to make decisions, etc.

5 - Importance of understanding scientific facts,concepts,laws,etc.

6 - Importance of developing the skills of reading and understanding science related materials

7 - Importance of developing scientific attitudes such as withholding judgment, perseverance, patience, etc.

8 - Importance of preparing students for next year's science program

9 - Importance of understanding the relationship between science, technology and society

10 - Importance of developing an awareness of the practice of science in Canada

11 - Importance of relating science to career opportunities

Low

(From Tables 1-11 Appendix 2)

The "effectiveness" of Curriculum Guides were considered by respondents to be "effective or very effective" on the scale (high 1) - (low 11) for the following factors in meeting program objectives:

High — Objectives

1 - Effectiveness developing social skills

2 - Effectiveness of developing curiosity and creativity

3 - Effectiveness of developing the skills and processes of investigation such as observing, etc.

4 - Effectiveness of the understanding scientific facts, concepts, laws, etc.

5.5 - Effectiveness of developing problem solving skills

5.5 - Effectiveness of developing the skills of reading and understanding science-related materials

7 - Effectiveness of preparing students for next year's science program

8 - Effectiveness of developing scientific attitudes

9 - Effectiveness of understanding the relationship between science, technology and society

10 - Effectiveness of relating science to career opportunities

11 - Effectiveness of developing an awareness of the practice of science in Canada

Low

(From Tables 12-22 - Appendix 2)

I B. The following factors were rated (High 1 - Low 11) on the scale in terms of a "minor/major aid" in achieving program objectives:

High Objectives

1 - Manitoba Science Curriculum Guide

2 - Students' interest

3 - Attitude toward teaching

4 - Textbook(s)

5 - Students' abilities

6 - Facilities, equipment and supplies

7 - Administrative support

8 - Support of professional organizations

9 - Community support

10 - Preparation time

11 - School timetable

Objectives

(From Tables 23-33 - Appendix 2)

II A.

The K-6 Science Curriculum Guide of the Department of Education specifies a number of units of study for each grade level. Three areas of concern were surveyed, (a) teacher teaching time for each unit of study at each grade level, (b) usefulness of the K-6 Curriculum Guide for teaching the unit, (c) difficulty level for students to learn the unit.

Grade 1 Curriculum Guide

- varied amounts of teaching time are spent by teachers to teach the units of study; (9-15), (16-23), and (24-33) units of time appear to be the most common proportions of time used for teaching the units.
- seventy-five percent of the respondents considered the units of study in grade 1 science to be "useful or more than useful".
- seventy-six percent of the respondents considered the units of study in grade 1 science as appropriate for the program. However, (14%) of the respondents considered Properties of Materials and Change to be too difficult.

(From Table 34 - Appendix 2)

Grade 2 Curriculum Guide

- varied amounts of teaching time are spent by teachers to teach the units of study; however the Biological unit varied from 9 to over 31 units of instruction time.
- respondents considered the units of study most useful with the Biological unit having the highest percent of "very useful" responses.
- seventy-three percent of the respondents considered the units of study appropriate.

(From Table 35 - Appendix 2)

Grade 3 Curriculum Guide

- seventy-three percent or more of the respondents considered the units of study to be most useful.
- the majority of the respondents considered the units of study appropriate with the Biological unit receiving the most favorable rating (78%).
- there was a small percentage (approximately 5%) except for the Biological unit of study of respondents who indicated that they do not teach the units of science.

(From Table 36 - Appendix 2)

Grade 4 Curriculum Guide

- (16-23) percentage of instruction was the most prevalent teaching units of time spent by the respondents on the units of science.

- the majority of the respondents considered the units of study in science to be most useful.

- most units of study were considered appropriate; however, 11% of the respondents considered Electricity and Sound and 23% Structures and Forces as "too difficult for study.

- also, there were varying percentages of respondents (5%) "Sound" to (13%) "Structures and Forces" who indicated that they do not teach the units of study.

(From Table 37 - Appendix 2)

Grade 5 Curriculum Guide

- (9-15) and 16-23) units of time were used by at least 15% of the respondents teaching the units of study with the exception of the Biological unit where there was a variation of percentages of teachers teaching the unit.

- at least (74%) of the respondents considered the units of study useful or very useful.

- the Biological unit had the greatest percentage of "usefulness" by respondents.

- most respondents found the units of study "appropriate" except (14%) "Forces and Motion" and (26%) "Physical and Chemical Changes" as "too difficult" units.

- approximately (6%) of all respondents did not teach the units of study.

(From Table 38 - Appendix 2)

Grade 6 Curriculum Guide

- the majority of the respondents used (9-15) and (16-23) units of time for teaching the units of study in grade 6 science.

- the majority of the respondents considered the units of study most useful, particularly the Biological unit which (87%) of the respondents indicated the "most favorable" use of the topic.

- from a (59%) "appropriate" respondent reply for "Forces and Machines" to a (75%) appropriate respondent reply for "Interaction of Population with the Environment", the units of study were judged appropriate for teaching. 14% of the respondents considered the Forces and Machines Unit too difficult.

- It should be noted that (10%) of the respondents indicated that they did not teach the unit of study, "Electric Charges".

(From Table 39 - Appendix 2)

II. B Factors which affect the teaching of science

The following factors were rated as "high" on the following order of priority by respondents.

High

1 - There is insufficient preparation time during school hours.

2 - Shortages of equipment and/or poor facilities.

3 - There are too many extra-curricular interruptions.

4 - Texts and other resource material are not always available.

5 - The timetable does not offer enough periods per week for science.

6 - Mainstreaming.

7 - Too much time is spent on extra topics not in the curriculum.

8 - Science time is used for other studies.

9 - Parts of the core curriculum are simply too long.

Low

(From Tables 40-48 - Appendix 2)

It should be noted that respondents who taught at the upper grades tended to rate the items 1-4 at a higher level on the scale whereas respondents who taught at lower grade levels rated them 6-9 at a lower level on the scale.

III. The order of classroom activities which respondents indicated that students had been engaged in their science lessons.

Activities are ranked below on level of activity by respondents performing the activity every lesson or about once or twice a week as a benchmark for the activity.

High

1 - Discussing why things happen in nature

2 - Classifying objects and events

3 - Communicating the results of an activity or investigation

4 - Collecting and interpreting data from an activity or investigation

5 - Doing a work sheet or a handout in class

6 - Copying notes from the chalkboard or the overhead projector

7 - Making notes during activities

8 - Reading in class from the science textbook(s)

9 - Listening to a lecture longer than 10 minutes

10 - Doing an experiment from a set of instructions

11 - Asking students to do science investigation at home

12 - Doing research on a science topic in the library

13 - Memorizing science facts

14 - Having students decide on the problems they wish to investigate

15 - Designing and conducting their own experiments

Low 16 - Working on the computer in science-related activities

(From Tables 49-64 - Appendix 2)

IV. The respondents' indication of their level of difficulty with evaluation of science.

High

1 - Students' ability to apply the scientific method

1.5 - Students' laboratory skills

1.5 - The processes of science

4 - Students' ability to communicate science

5 - Students' ability to solve problems

6 - The general goals and objectives for science

7 - The concepts of science

8 - Specific objectives from the K-6 Guide

Low 9 - Students' attitude toward science

(From Tables 65-73 - Appendix 2)

V. The importance of supplementary materials, aids, media with lessons ranked by respondents.

High

1 - Manitoba Science Curriculum Guide

2 - Audo-visual materials

3.5 - Materials from other teachers

3.5 - Teacher Textbook Guides

5 - Science magazines, journals, etc.

6 - Other science texts

7 - Supplementary information from Manitoba Education

8 - Student texts

9 - Commercially prepared kits

10 - School Division prepared materials

11 - Teacher Association materials

12 - Government publication materials

13 - Computer software

Low

(From Tables 74-86 - Appendix 2)

VI A. The principal science teaching room used by the respondents was the classroom and this percentage diminished from a (95%) for grade 1 respondents to that of (74%) for grade 6 respondents.

(From Table 87 - Appendix 2)

VI B. Fifty-eight percent and better of the respondents considered their physical facility for teaching science to have "inadequate or very inadequate" table, storage, plant/animal space and electrical/water outlets.

The respondents teaching at the lower grade had a greater percentage of inadequacy of their physical facility properties.

(From Tables 88-92 - Appendix 2)

VII A. Twenty-nine percent of the respondents indicated that they teach in multi-graded classrooms. The lowest percentage (24%) of the respondents were identified in grades 3 and 5 whereas the largest percentage (36%) of the respondents was identified in grade 2.

(From Table 93 - Appendix 2)

VII B. The respondents who taught in a multi-graded classroom considered some level of difficulty (16%) in teaching in a multi-graded classroom.

(From Table 94 - Appendix 2)

VII C. The respondents who taught in a multi-graded classroom identified the following level of major problems of teaching in a multi-graded classroom.

High

1 Range of abilities

1.5 Providing science equipment for all levels of students

1.5 Being able to accommodate the learning processes for the range of students

1.5 Having adequate learning materials/textbooks

5 Having suitable physical facilities

5.5 Number of students

Low 5.5 Special kind of students

(From Tables 95-101 - Appendix 2)

VIII. Level of value of professional development activities/programs identified by respondents

Useful or very useful

High

1 Divisional inservices

2 Science programs at SAG

3 Visits to other science teachers' classrooms

4 Other science conferences

5 Workshops presented by Department of Education consultants

6 Organized meetings with science teachers

7 University science education courses

8 University science courses

Low

(From Tables 102-109 - Appendix 2)

A significant percentage of respondents have not attended the various professional activities/workshops, e.g., SAG (39%), workshops presented by Department of Education consultants (54%), meetings with other science teachers (60%).

VIII. The eight most important topics for inservices selected by the respondents by level of importance:

High	1	Techniques for teaching science
	2	Available science resources
	3	How to prepare science activity kits
	4	Science as a way of thinking (e.g., enquiry)
	4.5	How to handle and organize varying abilities of students in science activities
	4.5	Methods of evaluating science processes
	7	How to develop detailed modules
Low	8	Science processes

(From Table 110 - Appendix 2)

IX A. Fifty-three percent of the respondents had taught 11 or more years with the exception of grade 3 respondents which was (49%).

A maximum amount of (27%) of the respondents taught science for any category of "years" of experience indicated.

(From Table 111 - Appendix 2)

IX B.

- (14%) of all respondents have not taken a science course since teaching
- (28%) of all respondents have taken a science course prior to 1970
- (15%) of all respondents have not taken a science education course since teaching
- (28%) of all respondents have taken a science education course prior to 1970
- (12%) of all respondents have not taken a university course since teaching
- (46%) of all respondents across all year levels have taken a university course since 1980.

(From Table 112 - Appendix 2)

C. - Biology and general science were the most prevalent courses taken by the respondents who had indicated that they had taken post-secondary courses.

(Table 113 - Appendix 2)

CONCLUSIONS

1. A large percentage of teachers have difficulty with teaching science skills and processes in the classroom.

2. Teachers appear to lack the opportunity/or do not have the opportunity to attend professional workshops/inservices.

3. Teachers prefer school division and subject area inservices.

4. Teachers in grades 1-6 use the Curriculum Guides and audio-visual materials as their primary source of supplementary materials, whereas computer software is the least used.

5. Teachers in grades 1-6 science have a low level of classroom activity in experiment activities.

6. The grade 4 teachers had the greatest percentage of respondents who did not teach the various units of study in the grades 1-6 Science Curriculum.

7. Grades 1-6 teachers appear to be most inclined to teach biological study units/activities in the Science Curriculum.

8. It would appear that grade 1-6 teachers have no strong feeling or association with associations/organizations.

9. Science teachers in grades 1-6 require inservices relating to techniques of teaching science, science activity kits and information on resource materials.

10. Teachers in grades 1-6 have taken more university credit courses rather than science or science education courses.

11. Science Curriculum Guides, grades 1-6, are a major aid to the teachers.

12. Schools teaching grades 1-6 science appear to have inadequate physical facilities.

RECOMMENDATIONS

1. It is recommended that high priority be given to inservicing teachers in science to meet their professional needs.

2. It is recommended that the process of teacher development in science be reviewed by/with Department of Education, University Faculties of Education, Manitoba Teachers' Society, Manitoba Association of School Trustees, and other concerned parties.

3. It is recommended that school administrators make provision for adequate science supplies and equipment to provide for inquiry/experimentation science classes.

4. It is recommended that schools provide adequate funds for science magazines and other science reading materials.

5. It is recommended that science teachers provide teaching methods in science to enhance higher level thinking skills and problem solving lessons for students.

6. It is recommended that supplementary materials be provided in the Science Curriculum or the Science Curriculum be reviewed to address concerns about the level of difficulty in the following:

    - forces and motion (all grades)
    - physical and chemical change (grade 5)
    - measuring time (grade 2)
    - electrical charges (grade 6)
    - properties and materials (grades 1 and 2)
    - change (grade 1)

7. It is recommended that all new school buildings for grades 1-6 include proper science facilities/rooms.

8. It is recommended that all grade K-6 science teachers increase the level of classroom activity involving experiment activities [from conclusion #7].

CHAPTER 10

SUMMARY AND RECOMMENDATIONS

The 1986 Science Assessment provides data from four different sources: 1. The Written Test Component, 2. The Performance Test Component, 3. The Comparison Test, and 4. The Teacher Survey. This chapter presents a summary of each data source and makes recommendations which are based on an interpretation of the cumulative results.

GRADE 3

Written Test Component - The written test results indicated that Grade 3 students generally understand the content and processes of science that compose the current Grade 3 Provincial Science Curriculum. However, the nature of the written responses provided by students yields evidence which shows that grade three students had a significant degree of difficulty providing complete and precise written responses. These students were not familiar with the concept of extinction in plants and animals.

Student mean scores were lowest in the categories of Problem Solving and Decision Making. In the affective domain, student responses indicated a generally positive attitude toward science. However, these results also indicate that Grade 3 students generally did not know which magazines and television programs are scientific in nature or what the prevailing issues in science are. In the categories of Valuing Science and Adopting Attitudes of Science, Grade 3 students had a reasonably accurate conception of the impact of science on their lives.

Performance Test Component - Although students appeared to have had little difficulty answering the process items on the written test, observation of student performance indicated some deficiency in the area of measurement skills, data collection and interpretation, making inferences, prediction, and explaining physical phenomena.

Comparison Test Component - The comparison tests were administered to Grades 5, 8, and 11 (the grade levels tested in 1980). The Grade 5 results for this component are most comparable to the Grade 3. The Grade 5 students achieved best in the processes of science and performed most poorly for the topics related to physical science and earth science/weather.

Teacher Survey Component - The teacher survey indicated that:

1. In general, Grade 3 teachers said that they had difficulty in teaching science skills and processes.

2. About 50% of Manitoba Grade 3 teachers attend professional workshops/inservices.

3. Grade 3 teachers use few classroom activities involving experimental investigation where students are required to make judgements regarding their experimental design.

4. Grade 3 teachers are most apt to teach study units associated with the life sciences and least apt to teach those units of the curriculum associated with the physical sciences.

5. Many Grade 3 teachers do not feel that they have adequate facilities for teaching science.

6. Elementary teachers who teach science have a tendency to take university courses that are not associated with science or science education.

7. Most Grade 3 teachers use the Manitoba Education recommended curriculum guide.

8. Forty-nine percent of the Grade 3 teachers have taught for at least eleven years.

Recommendations for Grade Three

1. That elementary teacher education, at both the pre-service and in-service levels, place a greater emphasis on problem solving in science, investigative techniques in science and the treatment of experimental data in science.

2. That the official Grade 3 curriculum be modified to include a greater opportunity for students to receive experience in written and oral communication with respect to scientific inquiry and problem solving.

3. That school boards and administrators ensure that all elements of the Grade 3 core science curriculum are taught and are included in each science teacher's testing program.

4. That all teachers of Grade 3 science utilize classroom experiences that involve investigative techniques and relate the results of these investigations to society and to technology.

5. That provision be made by school administrators and other concerned bodies, to supply each teacher of science with adequate science supplies, equipment and reference materials and that these materials be current and well maintained.

6. That school boards and administrators ensure that every science classroom teacher has an adequate academic background (with respect to science) to teach their assigned level.

7. That high priority be given, by the appropriate agencies, to inservicing elementary teachers of science specifically in the content areas of Earth Science, Space Science, and the Physical Sciences. These programs must be of a degree of magnitude and duration which will meet the perceived need and thus promote greater student achievement in these identified content areas.

8. That all teachers and groups associated with science education stress the continued need for safety in the science curriculum, the science laboratory and the science classroom.

9. That the Curriculum Branch of Manitoba Education provide curriculum supplements which suggest activities for relating the concepts of science to the applications of science, technology and society. (STS)

GRADE 6

Written Test Component - The written test results for Grade 6 students showed that students performed satisfactorily on less than half of the categories tested. Many of the satisfactory categories tended to be those associated with what might be termed, "traditional science", for example, the learning of facts and concepts. Students had difficulty with items requiring written responses and explanations. They performed most poorly on items associated with the Physical Science and Earth Science themes.

In the affective domain it was noted that students preferred doing science rather than watching films or reading about science. While a degree of polarization of attitude was indicated, generally Grade 6 students' attitudes towards science and careers in science were positive. There appeared to be a lack of knowledge relative to science and society topics and current issues involving science.

Performance Test Component - The Grade 6 students' ability to interpret data varied in accordance with the context of the performance task. Inferences and predictions were poorly done in the Station tasks, but were better for the Individual tasks. These students were relatively good at making and recording observations but evidenced weaknesses in the using of inquiry techniques, especially control of variables. They generally had difficulty with open-ended problems for which they had to design solutions.

Teacher Survey Component - The Grade 6 teacher survey indicates:

1. that teachers generally favour the Life Science theme in the Grade 6 curriculum guide, i.e., in terms of time allocation and number of activities.

2. that teachers did not like the Physical Science units in the Grade 6 Curriculum Guide and some omitted portions of these units.

3. that most teachers discussed, "why things happen in nature", with their pupils, but few teachers had their pupils design and conduct their own experiments.

4. that teachers had a degree of difficulty evaluating their students' ability to apply the scientific method.

5. that more than 50% of the science teachers considered their physical facility for teaching science inadequate.

6. that a significant percentage of Grade 6 science teachers did not attend professional activities and workshops.

7. that K-6 science teachers in Manitoba schools did not conduct lessons involving a science experiment frequently.

8. that K-6 teachers felt the greatest need for inservices in the area of, "techniques for teaching science".

9. that more than 50% of the Grade 6 teachers had taught 11 years or longer.

Recommendations for Grade Six

1. that Grade 6 teachers place a greater instructional emphasis on:

    a) the use and understanding of the terminology of science.
    b) higher cognitive levels of thinking, i.e. explanations of physical phenomena.
    c) analysis and interpretation of data.
    d) graphing techniques.
    e) model development for explanation of physical phenomena.
    f) problem solving and decision making.
    g) written and oral records of science investigations.

2. that the Grade 6 curriculum be modified to include a greater number of open-ended activities requiring students to make decisions relative to inquiry investigations, e.g.: How will I conduct the investigation?, What data should be collected?, How should the data be analyzed?, What graphs will I use?, What are my conclusions?

3. That curriculum materials be identified or produced to complement the current Grade 6 curriculum in the areas of Science and Society, and Science and Technology.

4. That school boards and administrators ensure that all components of the core curriculum in science are taught, and pupils are evaluated accordingly.

5. That both in-service and university courses be made available for science teachers whose academic background is inconsistent with their teaching assignment.

6. That school boards and school administrators ensure that the academic preparation of each science teacher is suitable for his/her respective teaching assignment and that inadequately prepared teachers not be required to teach science lessons.

7. That all teachers, groups and agencies concerned with science education stress the continued need for safety with respect to the science curriculum, the science classroom and the science laboratory.

8. That provision be made to supply each science classroom with adequate laboratory equipment, supplies and reference materials.

9. That high priority be given to the establishment of a program for upgrading teacher knowledge and practice skills in the Earth, Space and Physical Sciences. This program will probably function best if it is school-based and includes the principal as an element of the support structure.

GRADE 9

Written Test Component - The written test component for Manitoba Grade 9 students indicates that the level of retention for the lower cognitive science content (facts and terminology) was relatively low (42% and 34% respectively). While facts and terminology are primarily memory items they are important enough to warrant consideration. In order to follow laboratory directions and to communicate the results of their experimentation pupils must have full knowledge of the facts and terminologies of science.

Grade 9 students performed relatively well on the difficult area of concepts and their relationships but, they were not able to communicate an acceptable level of knowledge and ideas associated with these concepts. For example only 13% were able to make two statements relative to the Big-Bang and Kinetic-Molecular Theories, 27% were able to explain physical phenomena, and only 26% were able to elaborate on current trends related to science.

Safety in the science classroom and the science laboratory is an area where we might reasonably expect 100% performance from students. Although our Grade 9 students received a 58% mean score for laboratory safety skills, there are areas of concern, such as 22% of our students saying they would not report a laboratory injury immediately after it occurs.

There is strong indication that our Grade 9 students have difficulty in identifying cause and effect variables and in controlling variables in an inquiry investigation or experiment. The results also show differences in the students' ability to respond to questions related to particular subject areas within the sciences. The subject areas of Earth Science and Physics were noticeably lower than Chemistry, Space Science, Life Science, and Environmental Science.

The affective portion of the written assessment shows that Grade 9 students generally have a positive attitude toward science. This portion of the assessment also indicates that these students are quite limited in their perception of Canada's contribution to developments in science.

Performance Test Component - The performance test component shows that Grade 9 students performed poorly in the area of identifying dependent and independent variables and in controlling variables in an inquiry investigation or experiment. This factor relates to the portion of the written assessment dealing with the processes of science whereby students appear to have had some difficulty with the process of hypothesizing and with integrating two or more processes. These results also indicate that while students do exercise care and are capable of demonstrating a number of laboratory skills, they had much difficulty relating the cognitive aspects that are to be learned in the classroom to the inquiry investigations in the laboratory. For example, students can manipulate the equipment for an investigation of a first-class lever but, they could not solve problems using the data associated with the lever. These results indicate a lack of congruence with respect to science instruction in the classroom and the science laboratory. The performance component of the assessment also indicates that Grade 9 students have difficulty with experimental techniques such as repeated data collection and organization of collected data.

There were adequate measurement and measurement related questions in both the written and performance components of the assessment to provide for a reasonably accurate estimate of student abilities in this area. The results indicate that students are either not receiving or not retaining instruction in the use of dimensional analysis when solving problems requiring the use of SI measurement. In some cases the difficulty may be with knowledge of SI terminology but in most cases the students simply do not seem to be aware of the importance of dimensions.

Comparison Test Component - The comparison tests were administered to Grades 5, 8, and 11 (the grade levels tested in the 1980 assessment). The Grade 8 and Grade 11 results for this component relate best to the 1986 Grade 9 written results. The grade 8 comparison results indicated that these students regressed in achievement over the five-year comparison period for all topics that were tested. They achieved best for the topic "Nature of Science" and worst for the topics relating to weather and to physical science. The Grade 11 results indicate an increase in achievement for the topics: Earth Science, Physical Properties and Safety in Science. A decrease in achievement (the 1986 results were lower than the 1980 results) was noted for the topics: Weather, Astronomy, Electricity and Magnetism, Force-Work and Energy, Heat and Temperature, and Light.

Teacher Survey Component - The 1986 Science Assessment program did not include a teacher survey for Grade 9. However, a teacher survey was administered by the Curriculum Branch of Manitoba Education to Grades 7, 8, and 9 teachers of science in 1985. The results of this survey indicate that many teachers, who are presently teaching in Manitoba public schools, do not have the diverse university course work that is generally considered necessary for effective instruction in Grade 9 general science. Regardless of a teacher's experience and ability to relate to students, he/she must possess a knowledge background that will allow for accurate, specific explanations and appropriate analysis and synthesis of the concepts to be learned. The cognitive aspects of the science curriculum at the Grade 9 level are sophisticated enough to provide serious instructional problems to the teacher who does not have the appropriate science course work and laboratory experience in both the physical and the life sciences.

Recommendations for Grade Nine

1. It is recommended that all teachers of Grade 7-9 science conduct frequent formative assessments to determine student knowledge of the facts and terminologies of the current science content and that where lack of knowledge is indicated remedial instruction should occur.

   Although lack of retention may be due to a number of factors, student motivation being an important one, it is expected that a student's ability to remember the important facts and terminologies of science will improve with greater frequency of assessment and rehearsal.

2. It is recommended that all teachers of Grade 7-9 science make a deliberate attempt to relate the facts and terminologies of science to the larger conceptual scheme embodying each, and wherever possible to integrate the respective concepts into larger, more encompassing theories. While this is certainly being done by many science teachers, the assessment results indicate that more emphasis must be given to this area.

3. Teachers should not be expected to be able to successfully teach Grade 7-9 science experience. In order to ensure that Manitoba school children will have the best possible instruction in science it is recommended that:

   a) Faculties of education ensure that their elementary and secondary degree programs require that each graduate have the necessary course work and laboratory experience to effectively teach the required science curriculum. ("Necessary course work and laboratory experience", must be defined through joint consultation of all involved bodies.)

   b) University courses, workshops and short courses be provided for practicing teachers who need them. Teachers in need will have to be identified and encouraged to participate in these upgrading programs.

4. While safety with respect to the science curriculum, the classroom or the laboratory has not been a serious problem in the Manitoba schools, the assessment results indicate that there is need for greater emphasis on science curriculum, classroom and laboratory safety. Preservice teacher training should stress the recognized safety factors. Short-term workshops on laboratory safety should be implemented and the concept of safety should be built into all science programs and curricula.

5. The Grade 7-9 Manitoba curriculum has much potential for generating inquiry situations that could give students practice in handling experimental variables. The actual investigations, however, are not "laid-on" and teachers must rely upon the textual materials to provide the needed inquiry investigations. This may not be sufficient for many teachers. It is recommended that inquiry material be provided in a systematic mode, in context with the concepts of the curriculum, for use by teachers at their judgement. A single text that is consistent with the curriculum objectives and used universally throughout the province may help to rectify this concern.

6. It is recommended that there be an immediate review of the Grade 7-9 science curriculum for the purpose of integrating activities which will provide teachers with a mechanism for allowing students to implement experiments of their own design. These activities should provide students with experience in hypothesizing and with the integrated processes of science.

7. It is recommended that a series of performance tests be developed and made available to teachers for administration on a regular basis. These tests would be designed to measure the utilization of learning outcomes of the classroom in the context of the laboratory inquiry investigations. The results of these tests will allow teachers to take action to remedy any noted student deficiencies while instruction is still in the formative mode.

8. In order to help alleviate the noted deficiency in the use of dimensions and the appropriate SI units, it is recommended that remediation be implemented in the form of workshops and supplementary curriculum materials for teachers. Because measurement and the application of SI units are not unique to science it is also recommended that the Curriculum Branch consider ways and means of integrating the teaching of SI units throughout all subject areas.

9. The intent of the Grade 7-9 science curriculum is that it follow a general science theme and that all subject areas be given adequate attention. The rationale for this approach is to educate Manitoba youth in science in a manner which will allow each student to have a diverse, but significant exposure to the major areas which constitute the discipline of science. Students who consistently miss out on either or both of their Earth Science and Physics instruction are bound to be penalized with respect to their future science endeavours. Consequently, it is recommended that some mechanism be implemented to ensure that at least adequate time be given to instruction in each area of science and that proper evaluation occurs in each of the areas.

10. In recognition of the possibility that the curricular emphasis on the abstractions of science may be partially responsible for a downward trend in student interest in science between grades 6 and 9, it is recommended that the Science and Society as well as the Technology components of science instruction be given emphasis in the form of better integration with the curriculum content. There is evidence to indicate that greater student retention of content occurs when factors such as Canada's contribution to science developments are taught in context with particular concept instruction.

APPENDIX 1

SCIENCE COMPARISON TESTING, 1980-85

The 1980 results are based on the sample sizes of 1425, 1395, and 1182 for grades 5, 8, and 11 respectively. The statistics for the attitudes items are based on the number of actual responses to these items.

The 1985 results are based on sample sizes of 777, 708, and 793 for grades 5, 8, and 11 respectively. Degrees of freedom for the three samples are 18, 12, and 7 respectively. As with the 1980 results, the statistics for the attitude items are based on the number of actual responses to these items; this was as low as 765, 648, and 652 for one of the attitude items at grade levels 5, 8, and 11 respectively.

The 1980 data were re-analyzed to reflect the questions actually used in 1985. The 1985 data were analyzed using a program developed by the Statistical Advisory Services at the University of Manitoba. Since two strata at grade 11 each contained only one school in the sample, a method known as inter-penetrating subsamples had to be employed to allow use of these data.

A summary of the results of the comparison testing can be found in Tables 38, 39, and 40 of Chapter 8.

SCIENCE COMPARISON 1985

NUMBER OF SCHOOLS AND DIVISIONS/DISTRICTS

Grade 5

STRATUM	Population Div/ Dist	Population Schools	Sample Div/ Dist	Sample Schools
1. Urban/Winnipeg	11	168	5	7
3. Hutterian	25	74	3	4
4. Othercity/Large Town	08	48	3	3
5. Northern Remote	12	44	1	2
6. Rural Sm Town - small school	33	131	4	4
7. Rural Small Town	32	80	4	4
Total:	121	545	20	24

52 SCHOOLS - 31 DIVISIONS/DISTRICTS

NUMBER OF STUDENTS

Grade 5

	1984-85 Figures		November, 1985 Figures		
STRATUM	Pop.	Sample	Reported	Obtained	
1. Urban/Winnipeg	7257	383	396	375	
3. Hutterian	192	12	14	14	
4. Othercity/Large Town	2119	122	117	108	
5. Northern Remote	747	43	49	36	
6. Rural/Sm Town - Small School	1666	107	111	108	
7. Rural Small Town	2797	147	141	136	
Total	14,778	814	828	777	

SCIENCE COMPARISON 1985

NUMBER OF SCHOOLS AND DIVISIONS/DISTRICTS

	Grade 8			
	Population		Sample	
STRATUM	Div/ Dist	Schools	Div/ Dist	Schools
1. Urban/Winnipeg	11	73	5	5
3. Hutterian	10	74	3	3
4. Othercity/Large Town	12	26	1	2
5. Northern Remote	13	40	2	2
6. Rural Sm Town - small school	33	121	3	4
7. Rural Small Town	27	57	2	2
Total:	106	391	16	18

52 SCHOOLS - 31 DIVISIONS/DISTRICTS

NUMBER OF STUDENTS

Grade 8

	1984-85 Figures		November, 1985 Figures		
STRATUM	Pop.	Sample	Reported	Obtained	
1. Urban/Winnipeg	7614	399	382	333	
3. Hutterian	150	7	5	5	
4. Othercity/Large Town	2388	123	146	122	
5. Northern Remote	799	46	47	35	
6. Rural/Sm Town - Small School	2171	114	118	106	
7. Rural Small Town	2119	131	113	107	
Total	15,241	820	811	708	

SCIENCE COMPARISON 1985

NUMBER OF SCHOOLS AND DIVISIONS/DISTRICTS

Grade 11

STRATUM	Population Div/ Dist	Population Schools	Sample Div/ Dist	Sample Schools
1. Urban/Winnipeg	11	38	1	1
3. Hutterian	-	-	-	-
4. Othercity/Large Town	9	12	2	2
5. Northern Remote	9	16	2	2
6. Rural Sm Town - small school	26	66	4	4
7. Rural Small Town	19	23	1	1
Total:	74	155	10	10

52 SCHOOLS - 31 DIVISIONS/DISTRICTS

NUMBER OF STUDENTS

Grade 11

	1984-85 Figures		November, 1985 Figures		
STRATUM	Pop.	Sample	Reported	Obtained	
1. Urban/Winnipeg	8694	447	431	372	
3. Hutterian	-	-	-	-	
4. Othercity/Large Town	2669	284	198	197	
5. Northern Remote	551	38	45	31	
6. Rural/Sm Town - Small Town	1993	108	98	88	
7. Rural Small Town	1807	121	114	105	
Total	15,714	998	886	793	

APPENDIX 2

I. CURRICULUM GUIDES

A. IMPORTANCE OF PROGRAM OBJECTIVES AND EFFECTIVENESS IN ACHIEVING THE OBJECTIVES.

"how important each item is for the teaching of science."

Table 1

1. The importance of understanding scientific facts, concepts, laws, etc. . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	1%	16%	59%	22%
2	0	14	51	33
3	0	9	54	33
4	1	4	47	47
5	0	6	53	40
6	0	9	55	34
AVERAGE	**0**	**10**	**53**	**34**

Table 2

2. The importance of developing social skills such as cooperation, a sense of responsibility, and the ability to communicate . . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	1%	4%	23%	73%
2	2	2	33	61
3	0	2	38	56
4	1	5	30	63
5	0	6	39	54
6	0	5	34	59
AVERAGE	**1**	**4**	**32**	**62**

Table 3

3. The importance of developing problem solving skills such as clarifying the problem, designing possible solutions, and the ability to make decisions, to solve numerical problems, etc. . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	3%	5%	41%	52%
2	2	16	39	41
3	0	10	38	48
4	0	4	39	56
5	2	8	44	44
6	0	3	31	64
AVERAGE	**1**	**7**	**38**	**51**

Table 4

4. The importance of relating science to career opportunities. . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	18%	50%	26%	5%
2	24	39	31	4
3	12	34	41	7
4	12	42	34	9
5	9	40	41	7
6	5	34	47	13
AVERAGE	**14**	**40**	**36**	**8**

Table 5

5. The importance of developing the skills of reading and understanding science-related materials . . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	4%	23%	41%	31%
2	1	17	53	26
3	2	7	63	24
4	1	8	52	38
5	0	6	55	37
6	0	11	50	36
AVERAGE	**1**	**13**	**52**	**32**

Table 6

6. The importance of understanding the relationship between science, technology, and society. . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	14%	40%	36%	10%
2	9	39	39	9
3	6	26	44	18
4	2	21	51	24
5	2	20	57	17
6	1	20	50	25
AVERAGE	**6**	**28**	**46**	**17**

Table 7

7. The importance of developing scientific attitudes such as withholding judgement, perseverance, patience, and scientific integr

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	7%	20%	46%	24%
2	6	22	49	19
3	3	14	52	24
4	4	11	44	40
5	2	18	59	18
6	1	9	57	30
AVERAGE	**4**	**16**	**51**	**26**

Table 8

8. The importance of developing curiosity and creativity . . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	1%	0%	22%	77%
2	1	1	23	73
3	1	0	24	71
4	0	1	20	77
5	0	1	30	68
6	1	1	22	73
AVERAGE	**1**	**1**	**23**	**73**

Table 9

9. The importance of developing the skills and processes of investigation such as observing, classifying, and hypothesizing . . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	0%	5%	35%	60%
2	2	3	42	51
3	0	5	41	50
4	0	0	35	64
5	0	2	46	51
6	0	1	34	63
AVERAGE	**0**	**3**	**39**	**57**

Table 10

10. The importance of developing an awareness of the practice of science in Canada . . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	21%	42%	30%	5%
2	17	40	33	8
3	10	38	39	9
4	9	40	37	11
5	8	43	38	10
6	3	31	55	9
AVERAGE	**12**	**39**	**38**	**9**

Table 11

11. The importance of preparing students for next year's science program . . .

Grade	Of No Importance	Of Little Importance	Important	Very Important
1	5%	24%	50%	19%
2	4	23	54	17
3	4	22	56	13
4	6	26	48	18
5	5	29	54	9
6	7	35	48	8
AVERAGE	**5**	**26**	**52**	**14**

"how effective your teaching is in achieving each item."

Table 12

12. The effectiveness of understanding scientific facts, concepts, laws, etc. . . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	3%	25%	63%	4%
2	0	24	60	12
3	1	17	68	7
4	0	16	71	11
5	0	14	70	11
6	0	16	65	16
AVERAGE	**1**	**19**	**66**	**10**

Table 13

13. The effectiveness of developing social skills such as cooperation, a sense of responsibility, and the ability to communicate.

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	1%	7	57%	32%
2	0	7	62	27
3	0	9	73	15
4	0	10	57	32
5	0	20	61	16
6	0	16	56	25
AVERAGE	**0**	**11**	**61**	**25**

Table 14

14. The effectiveness of developing problem solving skills such as clarifying the problem, designing possible solutions, and the ability to make decisions, to solve numerical problems, etc. .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	4%	16	60%	15%
2	2	27	53	15
3	2	22	64	6
4	2	20	60	16
5	2	32	54	6
6	0	22	61	14
AVERAGE	**2**	**23**	**59**	**12**

Table 15

15. The effectiveness of relating science to career opportunities

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	29%	42%	21%	[illegible]
2	28	45	17	[illegible]
3	23	41	27	[illegible]
4	17	52	23	[illegible]
5	21	49	23	[illegible]
6	11	51	31	[illegible]
AVERAGE	**22**	**47**	**23**	**2**

Table 16

16. The effectiveness of developing the skills of reading and understanding science-related materials?

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	4%	20	53%	17%
2	0	22	52	21
3	5	15	64	12
4	2	18	65	13
5	1	23	66	7
6	3	35	49	9
AVERAGE	3	22	58	13

Table 17

17. The effectiveness of understanding the relationship between science, technology, and society. . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	18%	44%	28%	3%
2	17	43	31	4
3	11	36	41	6
4	7	37	48	6
5	7	45	39	3
6	7	39	40	11
AVERAGE	12	41	37	6

Table 18

18. The effectiveness of developing scientific attitudes such as withholding judgement, perseverance, patience, and scientific integrity . . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	10%	31	44%	8%
2	8	39	41	6
3	5	35	47	6
4	5	28	52	13
5	8	45	38	5
6	2	36	47	8
AVERAGE	7	35	45	8

Table 19

19. The effectiveness of developing curiosity and creativity. . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	2%	8%	44%	41%
2	0	6	62	26
3	2	6	64	23
4	0	11	50	35
5	0	17	62	17
6	0	14	60	22
AVERAGE	1	10	57	28

Table 20

20. The effectiveness of developing the skills and processes of investigation such as observing, classifying, and hypothesizing . . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	2%	16	48	29%
2	2	17	52	26
3	0	20	56	20
4	0	13	57	29
5	1	16	60	20
6	0	20	59	17
AVERAGE	1	17	55	24

Table 21

21. The effectiveness of developing an awareness of the practice of science in Canada . . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	41%	34%	17%	0%
2	31	40	21	2
3	27	40	26	2
4	12	55	23	4
5	23	56	13	1
6	18	48	28	1
AVERAGE	26	45	21	2

Table 22

22. The effectiveness of preparing students for next year's science program. . .

Grade	Ineffective	Slightly Effective	Effective	Very Effective
1	7%	20	55%	11%
2	4	29	52	12
3	4	27	53	10
4	6	18	54	18
5	3	32	49	8
6	10	25	49	11
AVERAGE	6	25	52	12

B. PLEASE CIRCLE THE NUMBER TO INDICATE THE DEGREE TO WHICH YOU THINK EACH OF THESE FACTORS HINDERS OR AIDS IN ACHIEVING THE PROGRAM OBJECTIVES.

Table 23

1. Manitoba Science curriculum guide

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	1%	3%	11%	33%	50%
2	1	4	14	24	56
3	3	3	6	31	54
4	1	1	7	36	55
5	0	1	7	40	49
6	1	6	10	36	47
AVERAGE	1	3	9	34	52

Table 24

2. Textbook(s)

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	2%	3%	27%	45%	17%
2	4	4	25	46	16
3	6	4	17	54	16
4	2	2	7	49	40
5	5	5	8	54	28
6	8	11	14	48	19
AVERAGE	4	5	17	49	23

Table 25

3. My attitude toward teaching science

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	0%	9%	14%	23%	51%
2	1	12	13	14	58
3	0	4	15	24	54
4	0	3	10	17	69
5	1	3	9	26	57
6	0	8	9	24	59
AVERAGE	1	7	12	21	58

Table 26

4. The facilities, equipment and supplies

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	14%	21%	18%	21%	26%
2	14	22	48	23	32
3	11	28	20	18	21
4	15	16	13	20	35
5	24	15	8	26	25
6	14	23	7	28	28
AVERAGE	15	21	13	23	28

Table 27

5. Administrative support

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	4%	6%	51%	22%	15%
2	2	2	44	29	21
3	2	9	49	18	20
4	5	9	35	29	21
5	2	6	40	26	24
6	2	6	48	27	17
AVERAGE	3	6	45	25	20

Table 28

6. Support of professional organizations

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	5%	7%	48%	29%	9%
2	3	2	53	27	13
3	3	5	47	31	11
4	4	6	51	27	12
5	3	2	53	28	13
6	1	3	56	31	7
AVERAGE	3	5	51	29	11

Table 29

7. Community support such as parents, etc

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	5%	7%	47%	29%	11%
2	3	1	53	33	9
3	3	5	50	31	7
4	2	8	56	23	10
5	2	3	56	30	6
6	5	7	57	26	6
AVERAGE	3	6	53	29	8

Table 30

8. My students' interest in science

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	0%	2%	14%	21%	63%
2	0	2	7	27	62
3	1	5	9	33	[illegible]
4	0	7	8	30	54
5	0	6	14	37	[illegible]
6	1	9	8	42	[illegible]
AVERAGE	1	5	10	31	52

Table 31

9. My students' abilities in science

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	2%	13%	29%	38%	18%
2	0	8	32	40	19
3	2	7	34	38	15
4	3	12	24	38	21
5	5	11	28	41	13
6	1	9	34	40	15
AVERAGE	2	10	30	39	17

Table 33

11. Preparation Time

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	22%	22%	21%	19%	14%
2	22	28	21	8	19
3	27	28	17	11	16
4	26	16	22	13	19
5	20	29	20	16	15
6	18	20	27	19	15
AVERAGE	22	24	21	14	16

Table 32

10. Our school timetable

Grade	Major Hindrance	Minor Hindrance	Not a Hindrance or Aid	Minor Aid	Major Aid
1	4%	21%	49%	17%	9%
2	5	11	52	15	17
3	7	14	46	21	10
4	7	17	45	21	9
5	9	17	52	11	9
6	9	15	43	26	7
AVERAGE	7	16	48	19	10

II. THE K-6 SCIENCE CURRICULUM GUIDE OF THE DEPARTMENT OF EDUCATION SPECIFIES A NUMBER OF UNITS OF STUDY FOR EACH GRADE LEVEL. PLEASE COMPLETE THE TABLE BELOW AS THE PROGRAM APPLIES TO YOU FOR THE GRADE LEVEL ONLY WHICH YOU ARE BEING SURVEYED:

A.

A) SELECT THE NUMBER BELOW WHICH BEST DESCRIBES THE TIME WHICH YOU SPEND TEACHING THE UNITS OF SCIENCE.

1 - [0-8%] 2 - [9-15%] 3 - [16-23%]
4 - [24-31%] 5 - [OVER 31%]

B) USEFULNESS OF THE K-6 CURRICULUM GUIDE FOR TEACHING THIS UNIT
1 - NOT USEFUL. . .
5 - VERY USEFUL

C) DIFFICULTY FOR STUDENTS TO LEARN THIS UNIT
1 - TOO EASY
2 - APPROPRIATE
3 - TOO DIFFICULT
9 - (DO NOT TEACH)

Table 34

Grade 1

	A					B					C			
						1 Not Useful - 5 Very Useful					1-Too Easy	Appro- priate	Too Difficult	Do No Teach
Units of Study	0-8	9-15	16-23	24-31	Over 31	1	2	3	4	5	1	2	3	9
a) Living and Non-Living Objects	6%	11%	10%	14%	4%	5%	7%	33%	32%	18%	9%	78%	2%	1%
b) Ourselves	4	9	11	13	8	5	9	34	26	23	5	80	2	3
c) Properties of Materials and Change	6	11	15	9	2	5	18	36	24	13	4	68	14	3
d) Comparing and Measuring Objects and Events	5	13	16	9	3	5	14	36	28	13	2	77	8	4

Table 35

Grade 2

	A					B					C			
						1 Not Useful - 5 Very Useful					1-Too Easy	Appropriate	Too Difficult	Do No Teach
Units of Study	0-8	9-15	16-23	24-31	Over 31	1	2	3	4	5	1	2	3	9
a) Properties of Living Objects	1%	7%	11%	12%	13%	3%	5%	28%	33%	21%	4%	77%	2%	0%
b) Properties of Matter	4	9	17	9	3	4	8	33	28	17	6	73	3	0
c) Measuring Objects and Position	12	11	15	5	0	5	6	36	28	11	2	73	6	3
d) Measuring Time	13	8	12	6	3	6	12	37	22	12	1	67	13	3
e) Properties of Materials Sand (Extension Unit)	24	5	3	0	0	11	9	26	9	5	0	26	2	47

Table 36

Grade 3

	A					B					C			
						1 Not Useful - 5 Very Useful					1-Too Easy	Appropriate	Too Difficult	Do No Teach
Units of Study	0-8	9-15	16-23	24-31	Over 31	1	2	3	4	5	1	2	3	9
a) Populations	11%	11%	14%	9%	4%	7%	7%	38%	16%	19%	9%	78%	2%	1%
b) Changes in Matter	9	16	19	4	2	3	6	36	22	21	1	65	9	5
c) Energy, heat and temperatures	10	12	20	4	3	2	7	36	21	19	0	65	10	5
d) Air and Air Pressure	11	14	17	4	3	2	12	24	30	19	1	66	9	4
e) Sun, Moon, and Shadows	10	15	18	4	2	2	10	33	23	17	1	61	13	6
f) Properties of Liquids (Extension Unit)	28	9	2	2	2	6	9	29	13	7	0	33	5	35

Table 37

Grade 4

	A					B					C			
						1 Not Useful - 5 Very Useful					1-Too Easy	Appropriate	Too Difficult	Do No Teach
Units of Study	0-8	9-15	16-23	24-31	Over 31	1	2	3	4	5	1	2	3	9
a) Population Interaction	5%	11%	22%	8%	3%	3%	11%	28%	29%	16%	2%	71%	5%	11%
b) Electricity	5	9	22	11	1	5	6	30	30	20	1	73	11	6
c) Sound	2	11	24	10	1	4	4	35	20	24	2	74	11	5
d) Structures and Forces	9	12	20	4	3	5	17	31	14	16	1	54	23	13
e) Water and Land	9	8	22	7	0	4	10	29	23	21	4	67	9	11

Table 38

Grade 5

	A					B					C			
						1 Not Useful - 5 Very Useful					1-Too Easy	Appropriate	Too Difficult	Do Not Teach
Units of Study	0-8	9-15	16-23	24-31	Over 31	1	2	3	4	5	1	2	3	9
a) Adaptations to the Environment	3%	10%	22%	9%	10%	1%	7%	33%	33%	18%	1%	79%	3%	5%
b) Forces & Motion	8	17	22	7	1	1	16	33	30	11	6	62	14	8
c) Physical and Chemical Changes	10	18	15	8	2	2	11	34	30	15	2	55	26	5
d) The Earth in Space	7	15	18	8	1	2	9	34	23	20		70	9	7
e) The Changing Earth	10	20	15	5	1	2	10	32	28	16	2	71	7	6
f) Cells and Organ Systems (Extension Unit)	30	3	5	1	0	6	5	26	15	5	1	26	8	43

Table 39

Grade 6

	A					B					C			
						1 Not Useful - 5 Very Useful					1-Too Easy	Appro-priate	Too Difficult	Do Not Teach
Units of Study	0-8	9-15	16-23	24-31	Over 31	1	2	3	4	5	1	2	3	9
a) Interaction of Population With the Environment	16%	14%	18%	5%	6%	7%	10%	28%	36%	13%	3%	75%	6%	5%
b) Changing and Preserving Our Environment	11	19	17	3	3	6	5	32	33	14	3	74	2	8
c) Forces and Machines	9	17	20	8	2	3	5	41	24	17	6	59	14	6
d) Electric Charges	8	19	22	6	1	5	2	36	30	16	7	61	6	10
e) Weather	8	26	17	5	1	3	9	36	31	14	3	66	8	5
f) Light (Extension Unit)	25	5	7	3	1	6	6	23	11	10	2	35	6	35

B. THE FOLLOWING FACTORS MAY AFFECT YOUR TEACHING OF SCIENCE. PLEASE RATE EACH FACTOR ON THE NUMBER SCALE FROM 1 (LOW) TO 5 (HIGH) AS TO THE EXTENT WHICH THE FACTOR AFFECTS YOUR TEACHING OF SCIENCE.

Table 40

1. The timetable does not offer enough periods per week for science.

Grade	Low 1	2	3	4	High 5
1	40%	16%	27%	10%	6%
2	38	15	25	11	8
3	19	20	33	12	12
4	24	22	26	17	10
5	31	14	23	14	17
6	28	13	24	18	16
AVERAGE	30	17	26	14	11

Table 42

3. There is insufficient preparation time during school hours

Grade	Low 1	2	3	4	High 5
1	17%	14%	22%	22%	25%
2	17	12	31	12	26
3	13	14	15	22	34
4	15	15	19	22	27
5	10	14	20	29	26
6	14	18	14	23	32
AVERAGE	15	14	20	21	28

Table 41

2. Shortages of equipment and/or poor facilities

Grade	Low 1	2	3	4	High 5
1	23%	15%	20%	16%	24%
2	15	17	25	18	22
3	5	20	23	22	27
4	20	11	18	21	28
5	14	9	24	17	33
6	18	19	17	17	28
AVERAGE	16	15	21	19	27

Table 43

4. Texts and other resource material are not always available

Grade	Low 1	2	3	4	High 5
1	23%	23%	20%	21%	13%
2	20	14	19	22	21
3	12	20	32	19	15
4	22	16	26	24	11
5	16	14	21	25	23
6	20	22	15	26	17
AVERAGE	19	18	22	23	16

Table 44

5. There are too many extra-curricular interruptions

Grade	Low 1	2	3	4	High 5
1	34%	14%	18%	18%	14%
2	22	18	34	8	13
3	22	13	20	21	19
4	19	19	15	24	21
5	22	13	15	28	22
6	16	14	20	26	24
AVERAGE	**23**	**15**	**20**	**21**	**19**

Table 45

6. Science time is used for other studies (computer education)

Grade	Low 1	2	3	4	High 5
1	40%	16%	25%	7%	11%
2	32	21	22	12	9
3	44	19	13	6	15
4	32	17	21	18	10
5	48	17	17	13	3
6	40	18	22	14	7
AVERAGE	**39**	**18**	**20**	**11**	**9**

Table 46

7. Mainstreaming, i.e., too many different groups in each class

Grade	Low 1	2	3	4	High 5
1	40%	20%	16%	14%	10%
2	29	16	24	8	18
3	29	20	21	16	10
4	29	18	26	13	14
5	30	20	20	16	10
6	27	25	14	14	20
AVERAGE	**31**	**20**	**20**	**14**	**14**

Table 47

8. Too much time is spent on extra topics not in the curriculum, e.g., science fair projects

Grade	Low 1	2	3	4	High 5
1	48%	21%	13%	16%	2%
2	40	25	20	9	2
3	41	20	16	13	7
4	36	17	16	19	10
5	41	23	14	16	5
6	31	16	27	14	12
AVERAGE	**40**	**20**	**18**	**15**	**6**

Table 48

9. Parts of the core curriculum are simply too long

Grade	Low 1	2	3	4	High 5
1	43%	23%	25%	5%	2%
2	26	22	38	4	3
3	18	15	37	14	11
4	26	26	32	12	4
5	20	23	32	16	6
6	18	20	33	20	8
AVERAGE	**26**	**21**	**33**	**12**	**5**

III. CLASSROOM ACTIVITIES

PLEASE INDICATE APPROXIMATELY HOW OFTEN YOU ENGAGE YOUR SCIENCE STUDENTS IN EACH OF THE FOLLOWING ACTIVITIES. (PLEASE CIRCLE ONE CHOICE ON EACH LINE.)

YOUR SCIENCE STUDENTS ARE ENGAGED IN

Table 49

1. Doing an experiment from a set of instructions

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	41%	50%	8%	2%
2	40	44	12	2
3	24	45	23	5
4	13	58	28	1
5	14	61	20	5
6	22	53	20	5
AVERAGE	26	52	18	3

Table 50

2. Designing and conducting their own experiments

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	64%	30%	5%	0%
2	67	27	3	1
3	63	30	4	2
4	51	46	3	0
5	62	37	0	0
6	51	40	7	1
AVERAGE	60	34	4	1

Table 51

3. Collecting and interpreting data from an activity or investigation

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	20%	52%	20%	7%
2	13	52	24	11
3	12	49	30	7
4	6	50	37	7
5	9	56	28	6
6	9	48	35	8
AVERAGE	12	51	29	8

Table 52

4. Communicating the results of an activity or investigation

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	4%	48%	32%	17%
2	7	45	29	17
3	7	38	34	18
4	3	44	41	11
5	6	51	33	9
6	11	41	31	17
AVERAGE	6	45	33	15

Table 53

5. Listening to a lecture longer than 10 minutes

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	66%	21%	12%	1%
2	55	26	13	5
3	47	35	15	1
4	40	22	34	2
5	30	28	33	7
6	26	35	25	11
AVERAGE	45	28	21	4

Table 54

6. Classifying objects or events

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	1%	22%	53%	24%
2	1	34	51	14
3	5	47	38	7
4	6	38	45	8
5	9	49	31	6
6	15	49	30	6
AVERAGE	6	39	42	11

Table 55

7. Doing a worksheet or a handout in class

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	32%	36%	26%	6%
2	19	38	32	11
3	23	39	27	7
4	27	42	28	3
5	24	38	30	7
6	32	36	31	1
AVERAGE	26	38	29	6

Table 56

8. Copying notes from the chalkboard or the overhead projector

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	74%	17%	6%	1%
2	62	22	14	1
3	37	37	21	2
4	29	32	35	3
5	16	29	44	10
6	20	27	42	10
AVERAGE	41	27	26	4

Table 57

9. Discussing why things happen in nature

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	2%	18%	37%	42%
2	3	22	34	40
3	0	14	45	39
4	2	18	46	33
5	0	20	43	36
6	1	18	36	44
AVERAGE	1	18	40	39

Table 58

10. Doing research on a science topic in the library

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	62%	28%	6%	1%
2	47	39	11	1
3	38	49	9	1
4	30	58	10	1
5	38	47	11	2
6	30	57	10	2
AVERAGE	42	45	10	2

Table 59

11. Reading in class from the science textbook(s)

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	66%	20%	11%	3%
2	63	21	12	3
3	45	36	13	4
4	33	31	30	7
5	25	24	37	13
6	41	24	25	10
AVERAGE	46	26	20	6

Table 60

12. Asking students to do science investigation at home

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	55%	38%	6%	1%
2	43	49	4	1
3	28	49	11	6
4	32	48	19	0
5	56	29	11	2
6	35	48	14	3
AVERAGE	42	44	11	2

Table 61

13. Memorizing science facts and concepts

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	87%	8%	2%	0%
2	78	18	3	0
3	63	26	6	2
4	52	30	12	5
5	30	49	17	1
6	44	35	15	5
AVERAGE	61	27	9	2

Table 62

14. Making notes during activities

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	71%	23%	2%	3%
2	59	27	9	2
3	39	36	15	6
4	21	37	32	9
5	10	38	44	7
6	13	45	30	12
AVERAGE	37	34	21	6

Table 63

15. Having students decide on the problems they wish to investigate

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	50%	41%	6%	2%
2	58	35	3	3
3	50	33	13	1
4	41	51	6	1
5	56	37	3	2
6	42	47	9	2
AVERAGE	49	40	7	2

Table 64

16. Working on the computer in science related activities

Grade	Almost never	About once or twice a month	About once or twice a week	Almost every lesson
1	82%	15%	1%	0%
2	83	13	3	0
3	74	16	4	1
4	76	20	3	0
5	83	11	5	0
6	73	20	7	0
AVERAGE	79	16	4	0

IV. EVALUATION PROBLEMS

SOME ASPECTS OF SCIENCE ARE MORE DIFFICULT FOR TEACHERS TO EVALUATE THAN OTHERS. PLEASE INDICATE YOUR FEELINGS CONCERNING DIFFICULTY OF EVALUATION FOR EACH OF THE FOLLOWING FACTORS. (PLEASE CIRCLE ONE NUMBER ON THE SCALE FOR EACH FACTOR.)

Table 65

1. The general goals and objectives for science

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	5%	23%	45%	23%	2%
2	6	18	44	23	4
3	6	24	38	24	2
4	4	20	40	30	4
5	8	31	44	14	1
6	6	28	35	24	5
AVERAGE	6	24	42	23	3

Table 66

2. The specific objectives from the K-6 Guide

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	4%	18%	39%	36%	1%
2	4	17	33	38	5
3	1	21	33	40	2
4	0	15	38	40	6
5	2	22	45	28	1
6	2	26	38	27	5
AVERAGE	2	20	38	35	3

Table 67

3. The processes of science

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	5%	32%	37%	21%	1%
2	8	27	32	25	2
3	5	31	34	28	0
4	5	37	33	20	3
5	3	45	31	17	0
6	6	35	32	22	3
AVERAGE	5	34	33	22	2

Table 68

4. The concepts of science

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	5%	26%	36%	25%	4%
2	1	23	27	38	1
3	1	22	35	37	2
4	2	19	29	38	11
5	0	21	32	41	2
6	1	19	27	41	9
AVERAGE	2	23	32	36	5

Table 69

5. The students' ability to solve problems

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	4%	28%	32%	32%	3%
2	2	18	39	38	1
3	7	29	29	29	4
4	6	32	29	30	2
5	3	33	30	30	1
6	1	35	24	35	2
AVERAGE	4	29	31	32	2

Table 70

6. The students' ability to apply the scientific method

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	12%	40%	30%	17%	0%
2	11	29	32	26	0
3	5	41	32	19	0
4	8	41	37	13	1
5	3	49	28	16	1
6	6	[illegible]	24	[illegible]	3
AVERAGE	8	39	27	21	1

Table 71

7. The students' ability to communicate science

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	8%	31%	35%	22%	4%
2	5	28	22	40	2
3	4	28	[illegible]	[illegible]	[illegible]
4	[illegible]	28	[illegible]	33	[illegible]
5	6	31	30	26	3
6	8	[illegible]	[illegible]	[illegible]	6
AVERAGE	5	30	31	29	4

Table 72

8. The students' laboratory skills

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	20%	22%	[illegible]	[illegible]	[illegible]
2	11	25	24	[illegible]	[illegible]
3	11	23	33	29	[illegible]
4	9	27	33	25	[illegible]
5	13	29	29	[illegible]	[illegible]
6	[illegible]	26	[illegible]	[illegible]	[illegible]
AVERAGE	14	25	31	27	[illegible]

Table 73

9. The students' attitude toward science

Grade	Very Difficult	Difficult	Neither	Easy	Very easy
1	9%	13%	25%	36%	16%
2	3	12	21	46	16
3	10	14	21	45	10
4	2	11	26	45	14
5	5	17	28	43	6
6	10	22	31	24	11
AVERAGE	7	14	25	40	12

V. LESSON PREPARATION

TEACHERS USE A VARIETY OF MATERIALS WHEN PLANNING INSTRUCTION. HOW IMPORTANT HAVE YOU FOUND EACH OF THE FOLLOWING TYPES IN YOUR PLANNING? (PLEASE CIRCLE ONLY ONE NUMBER ON EACH LINE WHICH DESCRIBES YOUR SITUATION.)

Table 74

1. Manitoba Science Curriculum Guide

Grade	Never Use	Of little importance	Fairly important	Very important
1	4%	16%	39%	41%
2	3	7	35	55
3	2	9	36	52
4	1	10	37	52
5	0	9	47	41
6	1	14	48	36
AVERAGE	2	11	40	47

Table 75

2. Teacher guides to student texts

Grade	Never Use	Of little importance	Fairly important	Very important
1	28%	27%	32%	12%
2	16	26	38	20
3	15	17	52	16
4	8	10	42	39
5	10	10	44	33
6	7	23	47	22
AVERAGE	14	19	42	23

Table 76

3. Student texts

Grade	Never Use	Of little importance	Fairly important	Very important
1	49%	23%	23%	4%
2	36	25	28	11
3	21	32	37	9
4	4	27	50	18
5	10	25	44	18
6	10	31	42	15
AVERAGE	23	27	37	12

Table 77

4. Other science texts

Grade	Never Use	Of little importance	Fairly important	Very important
1	22%	20%	45%	14%
2	14	16	59	12
3	11	38	40	7
4	7	20	55	14
5	6	33	40	18
6	7	26	51	14
AVERAGE	11	25	48	13

Table 78

5. Supplementary materials from: Manitoba Education

Grade	Never Use	Of little importance	Fairly important	Very important
1	34%	20%	35%	10%
2	24	22	33	20
3	22	21	38	14
4	26	28	27	17
5	24	23	38	10
6	27	32	27	10
AVERAGE	27	24	33	14

Table 79

6. Supplementary materials from: The School Division

Grade	Never Use	Of little importance	Fairly important	Very important
1	38%	22%	29%	7%
2	34	18	36	8
3	40	23	27	7
4	31	30	27	10
5	31	32	22	10
6	27	38	23	8
AVERAGE	34	27	27	9

Table 80

7. Supplementary materials from: Other teachers

Grade	Never Use	Of little importance	Fairly important	Very important
1	13%	14%	42%	30%
2	13	15	42	31
3	16	17	50	17
4	15	23	45	14
5	16	29	34	18
6	15	16	40	25
AVERAGE	15	19	42	23

Table 81

8. Supplementary materials from: Commercially prepared kits

Grade	Never Use	Of little importance	Fairly important	Very important
1	27%	29%	38%	5%
2	27	28	36	8
3	34	35	23	7
4	16	38	41	4
5	25	38	30	5
6	20	43	33	3
AVERAGE	25	35	34	5

Table 82

9. Supplementary materials from: Government publications

Grade	Never Use	Of little importance	Fairly important	Very important
1	38%	35%	22%	1%
2	33	29	33	5
3	31	40	23	4
4	21	39	34	5
5	25	45	25	2
6	22	50	23	5
AVERAGE	28	40	27	4

Table 83

10. Materials from teacher associations

Grade	Never Use	Of little importance	Fairly important	Very important
1	32%	29%	27%	6%
2	27	29	35	7
3	37	27	31	4
4	27	43	24	2
5	37	32	23	5
6	30	40	27	1
AVERAGE	32	33	28	4

Table 84

11. Science magazines, journals, etc.

Grade	Never Use	Of little importance	Fairly important	Very important
1	22%	14%	43%	19%
2	5	24	51	19
3	14	30	46	11
4	9	29	43	18
5	10	39	37	11
6	7	25	56	11
AVERAGE	11	26	46	16

Table 85

12. Audio-visual materials

Grade	Never Use	Of little importance	Fairly important	Very important
1	7%	13%	44%	35%
2	2	12	43	43
3	4	9	47	40
4	3	18	36	43
5	0	16	45	37
6	5	14	53	28
AVERAGE	4	13	44	38

Table 86

13. Computer software

Grade	Never Use	Of little importance	Fairly important	Very important
1	58%	15%	20%	4%
2	59	14	21	5
3	53	22	18	4
4	50	31	17	1
5	56	26	11	3
6	45	31	19	0
AVERAGE	54	23	18	3

VI. FACILITIES

PLEASE CHECK [✓] ONE.

Table 87

I teach science in

Grade	Class-room	Science lab	Both	Other
1	95%	0%	4%	1%
2	99	0	1	0
3	89	0	9	1
4	87	2	11	0
5	85	5	9	0
6	74	6	20	0
AVERAGE	**88**	**2**	**9**	**0**

B. THE PHYSICAL FACILITIES IDENTIFIED ABOVE FOR TEACHING SCIENCE IN MY SCHOOL ARE: (PLEASE CIRCLE A NUMBER TO CORRESPOND WITH YOUR SITUATION.)

Table 88

1. Table or counter space

Grade	Very Adequate	Inadequate	Adequate	More than adequate
1	22%	32%	41%	5%
2	20	37	40	3
3	27	34	37	2
4	33	33	28	7
5	33	28	31	6
6	33	27	28	11
AVERAGE	**28**	**32**	**34**	**6**

Table 89

2. Storage space for science materials and equipment

Grade	Very Adequate	Inadequate	Adequate	More than adequate
1	27%	34%	31%	7%
2	27	37	33	3
3	27	34	36	3
4	26	27	39	9
5	33	26	31	7
6	31	23	33	14
AVERAGE	**28**	**30**	**34**	**7**

Table 90

3. Plant/animal space

Grade	Very Adequate	Inadequate	Adequate	More than adequate
1	21%	41%	32%	5%
2	27	37	32	3
3	36	32	30	2
4	38	35	26	2
5	44	38	14	1
6	38	38	15	9
AVERAGE	**33**	**37**	**25**	**4**

Table 91

4. Water outlets/sinks

Grade	Very Adequate	Inadequate	Adequate	More than adequate
1	48 %	22%	23%	5%
2	58	20	20	2
3	49	27	21	3
4	54	12	26	8
5	61	18	11	6
6	43	18	25	14
AVERAGE	**52**	**19**	**21**	**6**

Table 92

5. Electrical outlets

Grade	Very Adequate	Inadequate	Adequate	More than adequate
1	23%	33%	33%	9%
2	28	21	44	6
3	23	32	40	4
4	20	19	50	10
5	26	24	39	8
6	26	26	33	14
AVERAGE	**24**	**26**	**40**	**9**

VII. TEACHING SITUATION

A. I TEACH IN A MULTI-GRADED CLASSROOM. (A MULTI-GRADED CLASSROOM IS DEFINED AS A CLASSROOM WHERE TWO OR MORE GRADES ARE TAUGHT.)

Table 93

I teach in a multi-graded classroom

Grade	Yes	No
1	29%	70%
2	36	62
3	24	70
4	32	68
5	24	74
6	25	73
AVERAGE	29	69

B. I FIND THAT TEACHING SCIENCE IN MY MULTI-GRADED CLASSROOM IS (PLEASE CIRCLE ONE CHOICE)

Table 94

I find that teaching science in my multi-graded classroom is

Grade	Very Difficult	Difficult	Neither	Easy	Easy
1	3%	9%	11%	4%	1%
2	1	21	8	3	0
3	4	7	10	4	0
4	4	15	9	1	1
5	8	13	3	1	0
6	3	9	8	2	0
AVERAGE	4	12	9	3	0

C. THE PROBLEMS OF TEACHING SCIENCE IN MY MULTIGRADED CLASSROOM ARE: (PLEASE CIRCLE A NUMBER ON THE NUMBER SCALE AS LISTED)

Table 95

1. the number of students

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	6%	6%	12%	4%	1%
2	9	8	7	5	3
3	13	4	5	2	1
4	11	5	9	4	2
5	9	5	3	2	5
6	9	3	7	3	2
AVERAGE	10	5	8	3	2

Table 96

2. the range of abilities

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	1%	4%	7%	12%	5%
2	1	4	7	11	5
3	3	3	5	13	2
4	2	4	8	12	4
5	1	3	3	7	4
6	1	2	5	6	
AVERAGE	2	3	6	10	7

Table 97

3. the special kinds of students, handicapped, etc.

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	16%	2%	5%	5%	1%
2	15	4	6	5	4
3	19	3	4	0	0
4	16	6	4	1	3
5	16	3	0	1	3
6	11	2	5	5	2
AVERAGE	16	3	4	3	2

Table 98

4. providing science equipment for the range of grades

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	7%	5%	4%	8%	6%
2	3	2	4	15	11
3	6	3	7	6	2
4	4	6	8	7	6
5	5	1	7	9	3
6	3	2	5	5	10
AVERAGE	5	3	6	8	7

Table 99

5. being able to accommodate the learning processes for the range of students

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	1%	5%	9%	10%	5%
2	1	4	11	12	7
3	3	3	9	9	3
4	1	2	13	9	6
5	1	3	5	8	7
6	0	3	5	8	8
AVERAGE	1	3	9	9	6

Table 100

6. having suitable furniture and physical environment

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	8%	4%	5%	8%	5%
2	3	1	12	12	7
3	3	5	6	9	1
4	2	5	4	11	9
5	2	3	6	6	7
6	3	2	5	5	9
AVERAGE	4	4	6	8	6

Table 101

7. having adequate learning materials/textbooks, etc.

Grade	Minor Problem 1	2	3	4	Major Problem 5
1	5%	2%	5%	12%	6%
2	7	2	7	12	6
3	6	1	6	7	4
4	1	4	10	11	5
5	0	3	6	7	8
6	3	1	7	5	8
AVERAGE	4	2	7	9	6

VIII. PROFESSIONAL DEVELOPMENT PROGRAMS

A. PLEASE INDICATE HOW USEFUL YOU FIND THE FOLLOWING PROFESSIONAL DEVELOPMENT PROGRAMS. (PLEASE CIRCLE ONLY ONE NUMBER FOR EACH STATEMENT.)

Table 102

1. Science Programs at SAC

Grade	Have not attended	Little or no use	Useful	Very Useful
1	51%	14%	31%	3%
2	39%	18	32	9
3	39	11	36	11
4	27	15	43	14
5	33	14	34	14
6	41	7	40	13
AVERAGE	39	13	36	10

Table 103

2. Other science conferences

Grade	Have not attended	Little or no use	Useful	Very Useful
1	56%	9%	29%	3%
2	54	9	28	6
3	49	10	32	6
4	37	15	39	7
5	48	10	31	6
6	45	9	35	9
AVERAGE	49	10	32	6

Table 104

3. Divisional inservices

Grade	Have not attended	Little or no use	Useful	Very Useful
1	23%	22%	45%	8%
2	24	15	47	11
3	20	16	47	14
4	21	28	40	9
5	28	20	41	8
6	23	19	43	15
AVERAGE	23	20	44	11

Table 105

4. Organized meetings with science teachers

Grade	Have not attended	Little or no use	Useful	Very Useful
1	64%	5%	18%	6%
2	64	5	18	11
3	61	6	20	9
4	59	14	16	7
5	57	7	26	6
6	53	5	31	9
AVERAGE	60	7	21	8

Table 106

5. Workshops presented by the Department of Education consultants

Grade	Have not attended	Little or no use	Useful	Very Useful
1	53%	8%	28%	7%
2	61	9	18	7
3	56	9	23	7
4	51	14	30	3
5	47	5	32	11
6	50	8	26	15
AVERAGE	54	9	26	8

Table 107

6. University science education courses

Grade	Have not attended	Little or no use	Useful	Very Useful
1	45%	26%	23%	4%
2	45	22	23	5
3	49	13	26	6
4	45	27	21	2
5	43	18	29	6
6	48	24	18	8
AVERAGE	46	22	23	5

Table 108

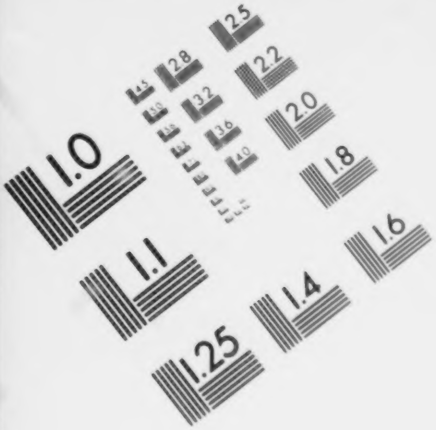
7. University science courses

Grade	Have not attended	Little or no use	Useful	Very Useful
1	47%	26%	23%	1%
2	49	27	16	3
3	46	24	26	0
4	43	26	23	4
5	45	21	22	8
6	43	19	24	11
AVERAGE	46	24	22	4

Table 109

8. Visits to other science teachers' classrooms

Grade	Have not attended	Little or no use	Useful	Very Useful
1	53%	3%	17%	23%
2	52	5	27	14
3	46	5	32	13
4	49	9	30	11
5	51	5	31	10
6	44	6	33	16
AVERAGE	49	5	28	15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AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

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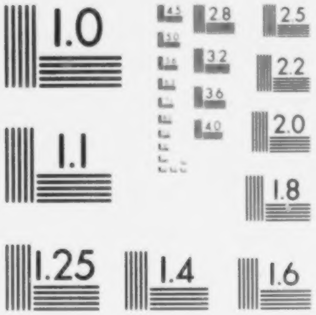
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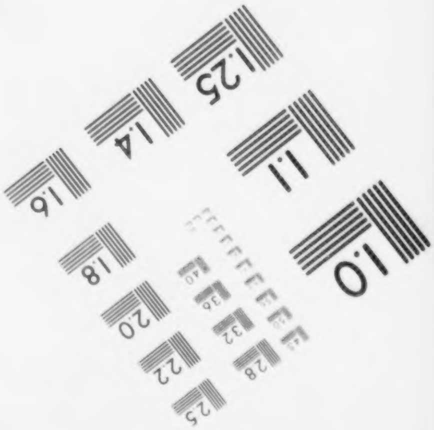
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MANUFACTURED TO AIIM STANDARDS
BY APPLIED IMAGE, INC.

B. WHAT TOPICS WOULD YOU LIKE FUTURE INSERVICE PROGRAMS TO FEATURE? (PLEASE IDENTIFY WITH A [✓] NO MORE THAN EIGHT TOPICS WHICH YOU FEEL WOULD BE HELPFUL TO YOU.)

Table 110

What topics would you like future inservice programs to feature

Grade	1*	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	71%	36%	71%	46%	15%	23%	59%	47%	27%	65%	6%	30%	25%	9%	27%
2	66	59	66	52	17	28	55	45	34	73	6	29	15	21	27
3	54	44	66	46	27	35	54	53	23	71	5	27	28	20	26
4	63	51	57	49	12	36	57	51	32	65	6	33	33	27	29
5	67	56	66	51	30	38	51	54	44	59	5	24	25	17	22
6	70	42	59	57	24	38	66	51	32	60	9	16	33	30	24
AVERAGE	**66**	**47**	**64**	**50**	**20**	**33**	**57**	**50**	**32**	**65**	**6**	**27**	**26**	**20**	**26**

* 1) Techniques of teaching science. . .

2) How to develop detailed modules. . .

3) How to prepare science activity kits. . .

4) How to handle and organize varying abilities of students in science activities. . .

5) Science content. . .

6) Science processes. . .

7) Science as a way of thinking (e.g., enquiry, problem solving). . .

8) Methods of evaluating science processes. . .

9) Methods of evaluating science content. . .

10) Available science resource material. . .

11) Teaching safety procedures. . .

12) Organizing and preparing field trips. . .

13) Self appraisal of teaching effectiveness. . .

14) Approaches to teaching science technology - society connections. . .

15) Sequencing science topics in multi-grade classrooms. . .

IX. EXPERIENCE IN SCIENCE AND SCIENCE TEACHING

A. I HAVE BEEN TEACHING IN THE CLASSROOM AS FOLLOWS:
(PLEASE [√] CHECK ONE ANSWER FOR EACH STATEMENT.)

Table 111

	Grade 1					Grade 2					Grade 3					Grade 4					Grade 5					Grade 6				
	*1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Teaching science(%)	3	25	12	19	21	3	23	25	13	21	7	27	20	7	20	6	17	14	18	23	9	25	18	13	18	8	19	24	18	22
Teaching generally	1	26	14	20	33	2	18	22	23	32	4	19	23	14	35	4	11	12	22	41	3	16	20	18	37	2	16	15	22	36

* 1 - 1st year   2 - 2-5 years   3 - 6-19 years   4 - 11-15 years   5 - 16 or more

B. I HAVE TAKEN THE MOST RECENT SCIENCE, SCIENCE EDUCATION, AND/OR UNIVERSITY COURSE AS FOLLOWS:
(PLEASE [√] CHECK ONE ANSWER FOR EACH STATEMENT.)

Table 112

	Grade 1					Grade 2					Grade 3					Grade 4					Grade 5					Grade 6				
Science Education	*1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Science Course (%)	19	14	12	13	21	20	16	14	18	16	22	19	10	12	14	14	17	19	13	12	14	26	16	15	11	22	14	23	13	11
Science Education Course	25	15	13	15	19	23	18	7	17	19	22	20	7	14	14	17	14	16	13	18	17	14	15	16	20	22	9	22	[illegible]	[illegible]
University Course (not science)	44	21	5	5	13	45	18	7	4	15	50	13	9	4	9	37	23	5	4	10	38	21	15	1	13	50	11	14	7	11

* 1 - 1980 to present   2 - 1975-1979   3 - 1970-1974   4 - Before 1970   5 - Nil [illegible]

C. **I HAVE TAKEN COLLEGE, UNIVERSITY, OR EQUIVALENT COURSES IN EACH OF THE FOLLOWING AREAS AS FOLLOWS:**
PLEASE CIRCLE THE NUMBER WHICH BEST DESCRIBES YOUR SITUATION.

Table 113

	Grade 1					Grade 2					Grade 3					Grade 4					Grade 5					Grade 6				
Subject	0	1	2	3	4+	0	1	2	3	4+	0	1	2	3	4+	0	1	2	3	4+	0	1	2	3	4+	0	1	2	3	4+
Astronomy	39%	10%	0%	0%	-	52%	8%	0%	0%	-	44%	10%	0%	1%	-	37%	11%	0%	0%	-	46%	13%	0%	0%	-	41%	13%	2%	0%	-
Biology	21	41	8	2	2	17	47	11	2	2	20	33	13	6	1	18	38	9	2	5	11	40	10	1	10	16	38	13	5	6
Chemistry	35	16	1	0	0	37	17	2	2	0	40	13	3	0	1	37	13	2	0	0	36	11	3	6	5	32	11	8	6	6
Earth Science (Geology)	32	16	5	0	3	37	23	2	1	1	38	18	6	0	2	26	17	10	0	3	34	17	7	6	1	36	16	2	1	7
Mathematics	23	17	13	6	1	24	21	8	7	7	29	17	13	2	9	24	23	7	2	2	23	21	6	5	13	14	23	9	6	10
Physics	41	6	0	0	0	47	8	0	1	0	44	12	0	2	2	39	5	2	0	1	41	11	5	1	2	30	15	6	3	3
General Science	23	31	11	4	1	28	35	5	1	1	30	29	9	5	1	19	31	8	3	0	28	22	7	2	2	23	23	13	0	5
Other science oriented courses (e.g., Kinesiology)	35	7	0	2	2	38	9	0	2	1	36	6	0	1	4	29	6	0	2	2	30	1	2	2	6	22	8	5	1	1

Appendix 16

END

U.S. Dept. of Education

Office of Education
Research and
Improvement (OERI)

ERIC

Date Filmed

March 29, 1991